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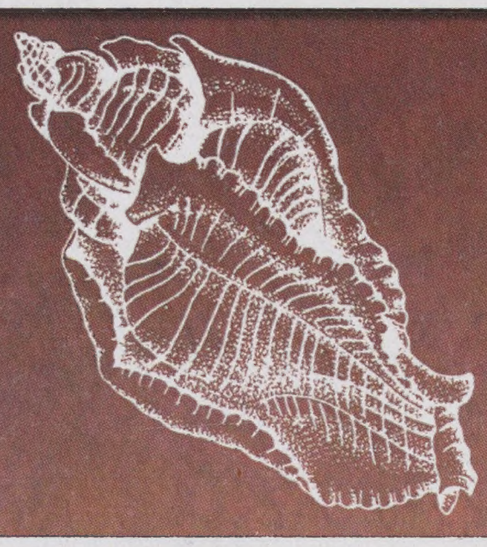

THE Festivus

Vol. 55(1) February 2023

Barycypraea from South Africa
Three new *Bistolida* species
Megastraea from the Californian Province
Venezuelan *Fasciolaria* revisited
A new *Pomaulax* from Korea

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Volume: 55 February 2023 ISSUE 1

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FRONT COVER:

Specimens of *Barycypraea fultoni* spp., arranged on a fossil slab (Photo courtesy of Michael Mont) (Cover artistic credit: Rex Stilwill).

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Impact Factor News: The Festivus just received its initial Impact Factor rating of 0.7 which puts this journal in the top 18% of peer reviewed journals worldwide. For comparison the highest Impact Factor which either The Veliger or The Nautilus had at their peak was 0.5, the International Journal of Malacology has an Impact Factor of 0.5, and Molluscan Research has an Impact Factor of 0.8.

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The Delta-shaped Maltese Cross Cowry *Barycypraea fultoni deltoidea* n. ssp., (Gastropoda: Cypraeidae) and a Further Discussion About Mozambican Populations and Observations of *Barycypraea* and Related Genera

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ABSTRACT A new subspecies, *Barycypraea fultoni deltoidei* found at shallow depths in the northern Transkei, South Africa is described herein. It differs from the nominate *B. fultoni* by the deltoidal shape and also by stronger development of the margins. A further analysis and discussion about Mozambican populations and a comparison of all four *B. fultoni* taxa are included. Differences in size, ratios, shape, margins, and bases between the taxa are described. Further observations of *Barycypraea* and related genera are discussed.

KEYWORDS *Cypraeidae, Barycypraea, B. fultoni deltoidea*, South Africa, Mozambique, new subspecies

INTRODUCTION

The Maltese cross Cowry *Barycypraea fultoni* (Sowerby III 1903) ranks among the most famous and sought-after species of the family Cypraeidae. Its unique color pattern, exquisite shape, rarity, and turbulent history which is described in the following sections, have all contributed to the mystery and fascination connected to this species.

Cypraea fultoni was described in 1903 by G.B. Sowerby III, in a book contribution entitled: Mollusca of South Africa, in Marine Investigations in South Africa, Volume II. The unique shell (See Figure 1) was apparently dredged, but damage to the parcel it was submitted in, caused the loss of exact locality data. Therefore, it was labeled; "from South Africa." The comprehensive description, beautiful illustrations, and the original specimen housed in the South African Museum (Registry number SAM A5053) allow a safe attribution of the name to typical, pyriform specimens of the South African population.

Franz Alfred and Maria Schilder (1938) commented on *B. fultoni*: "The South African *fultoni* and the Arabian *teulerei* are relics of the genus *Bernaya*, which was abundant in Eocene times," and gave the information on *B. fultoni*

Figure 1. *Barycypraea fultoni fultoni* Sowerby III 1903, holotype (60 millimeters), collection of South African Museum. Photo courtesy William Liltved.

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"mostly found in the stomachs of fishes." The fish is the musselcracker (*Cymatoceps nasutus* Castelnau, 1861).

A brief treatise of the species was given by C.M. Burgess (1970), who called it "one of the rarest species and one of the most unusual, since most specimens have been recovered from the stomachs of fish." [1] He illustrated an amazing shell, are described later in this article (See Type Locality, Distribution and Habitat section).

Before 1980, there were less than 40 specimens known from South Africa. Later on in the mid-1980s, Russian trawlers found thousands of specimens of *B. fultoni* around Mozambique. The following section will detail the populations found from Mozambique. One should realize that finding specimens around South Africa is still rare, with scattered findings made by dredging.

The Mozambican populations of *B. fultoni* were first discovered in early 1987, by Russian trawlers operating between Inhambane and Maputo in southern Mozambique. An American collector bought the then world record size of slightly less than 80 mm specimen for $22,000 (Beautiful Cowries Magazine No. 2 (2012), page 6). Since then three of these specimens were purchased by Dr. Luigi Raybaudi Massilia, one of them, measuring over 80 millimeters, at $25,000.00 US. This specimen was listed in the Guiness Book of World Records as the most expensive seashell ever sold. Another specimen was sold to the German collector Ludwig Gabrielli in 1988, and several more made their way to Raybaudi and other top collectors at that time.

The first printed picture of a Mozambican *B. fultoni amorimi massieri* (Lorenz, 1991) was illustrated on the cover of the "Sea Gifts" Sales catalogue on September 5th, 1988, issued by Steven Whatmough, a shell dealer from Cape Town, South Africa. The shell, measuring 67 mm, was said to come from South Africa. The inflated shape, pattern, and size clearly reveal its Mozambican origin. Steven did not know the exact provenance and later stated that the shell (See Figure 2) was found by a commercial fish trawler somewhere north of Durban (personal communication with Felix Lorenz 1989).

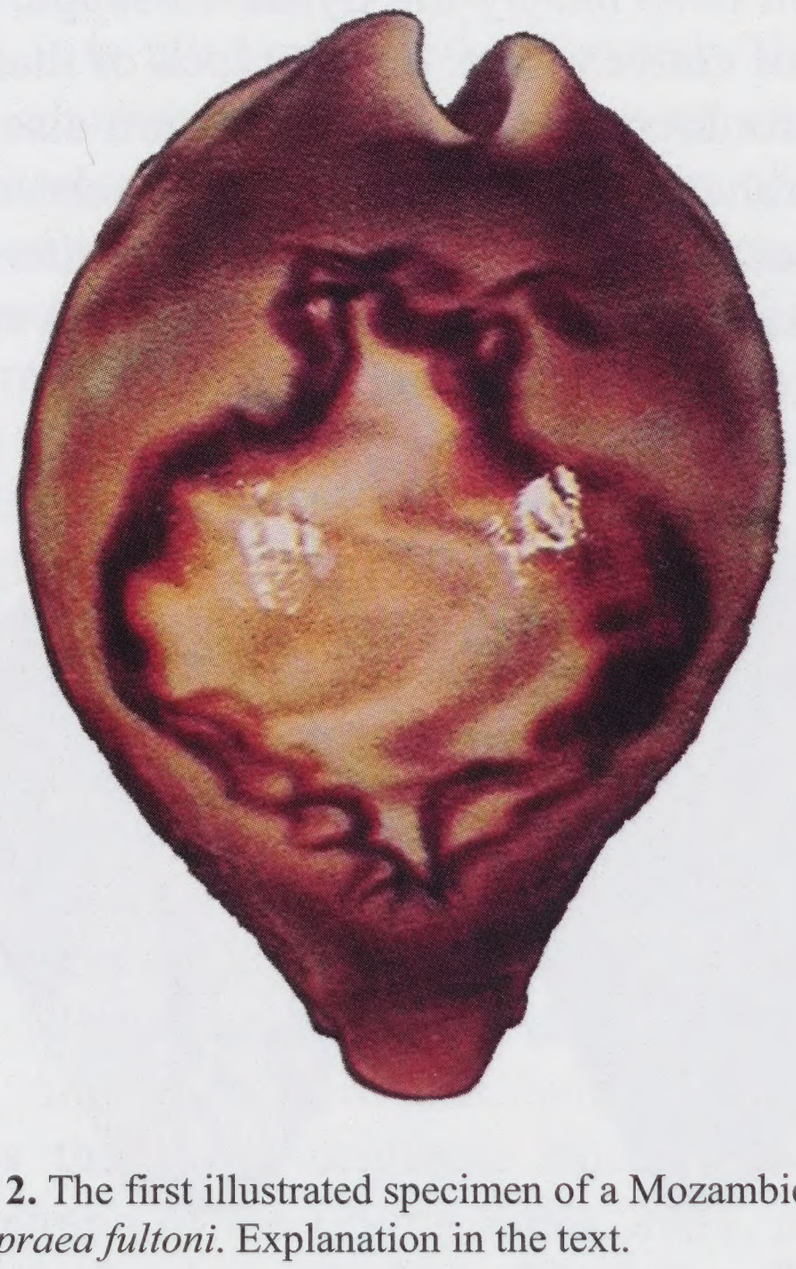

Figure 2. The first illustrated specimen of a Mozambican *Barycypraea fultoni*. Explanation in the text.

In 1989, the discovery of the northern (Mozambican) population was announced by Raybaudi (in The Connoisseur No. 22). By that time, large numbers of Mozambican specimens had become available at relatively affordable

[1] A student of biology reading about *fultoni* being recovered from the stomachs of fish questioned this information: "a seashell can impossibly live in the stomach of a fish"! (in a personal communication with Felix Lorenz, circa 2005).

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prices. In The Connoisseur magazine Number 23, Raybaudi subdivided the Mozambican shells into two groups: pyriform specimens, which he assigned to *B. fultoni fultoni*, with the taxonomically invalid name "*mozambicana,*" (which was described as a variety rather than a taxa) and extremely calloused, deltoidal shells, for which he proposed the subspecies name *B. fultoni amorimi* Raybaudi 1990.

As described by Lorenz in his work in 1991, the *"mozambicana"* form should be given a taxonomically valid name, as it differed considerably from the nominate South African *B. fultoni fultoni*. (Lorenz, 1991) With the consent of Raybaudi, Lorenz formally described *B. fultoni massieri* in 1991, which differs from *B. fultoni amorimi* by the pyriform shape, a flat instead of convex base, and the lack of marginal callus protuberances. This publication also gave a comprehensive analysis of the conchological differences between the nominate *B. fultoni* and the Mozambican shells, and a general overview on the genus *Barycypraea*.

Figure 3. *Barycypraea fultoni deltoidea*, *ex pisce*, South Africa. From Burgess (1970) Plate 4 Figure A, A1 - the exact locality, size, and whereabouts of this specimen are unknown. First published record of the new subspecies (though not appreciated at the time as a new subspecies).

In World Shells No. 9 (1994), Raybaudi challenged the subspecific status of *B. massieri* as he could assemble intermediate stages of *B. amorimi*, assuming that the heavily calloused shells are gerontic, adding the varietal name "*triangularis.*" He illustrated several Mozambican shells as "*fultoni* typica" (See Figure 3 and Figure 5) as supposedly from Natal, and introduced the varietal name "*miniatra*" for the nominate South African population. In his Tables 1 and 2, he tried to demonstrate that *B. amorimi* and *B. massieri* were gradual forms. However, while Table 1 shows specimens clearly not showing marginal callus (= typical *B. massieri*), Table 2 shows a South African *B. fultoni fultoni* (top row left), an inflated, but otherwise typical *B. massieri* (top middle), and six specimens of *B. fultoni amorimi* with varying degree of marginal callus well-discernible on their dorsal views.

In the Beautiful Cowries Magazine No. 2 (2012), Bergonzoni gave a detailed report on the species, with a comparison with fossil taxa of the genus. This study is a highly recommended reference as it gives a lot of interesting extra information and anecdotes. He perpetuated the usage of the name "*miniatra*" as a variety of *B. fultoni fultoni* from South Africa, and gave preference to the name earlier, taxonomically invalid name *mozambicana* over the legitimately introduced *B. massieri*. In his richly illustrated article, Bergonzoni did not mix up Mozambican and South African shells, and on comparing the illustrations of the Mozambican specimens carefully, the differences between *B. amorimi* and *B. massieri* once again are quite obvious.

In Lorenz & Hubert's first two "Guides" (1993, 2000), the status of *B. massieri* was still kept on the subspecies level, but in the checklist of the book "New Worldwide Cowries" (2002) Lorenz reduced its status to that of a variety of *B. amorimi*. In the recent "Cowries" Volume 1, Lorenz described the differences between South African *B. fultoni fultoni* and Mozambican

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populations: "In *fultoni fultoni*, the anterior extremity tapers gradually. The dorsal part of the anterior canal exceeds the pointed extremities in length, so that from dorsal view, the anterior tips are not visible. In all Mozambican shells (*amorimi* and its variation *massieri*), the tips on either side of the anterior extremity are swollen, forming ridges that are visible from dorsal view. Hence the anterior extremity is narrow below the dorsum and then widens slightly because of the produced tips" Page 318, paragraph 6) (...) (and on referring to the number of columellar teeth: "The most notable difference is the fewer, more widely spaced columellar teeth in *fultoni* (11-14 counted teeth in an average-sized shell of 60 mm), against the considerably denser and more numerous teeth in *amorimi* (16-20 in an average-sized shell of 70 mm)" (paragraph 9). Lorenz also mentioned that only in Mozambican populations, the dorsal nacre is usually granulose in fully adult specimens, whereas South African shells always have a smooth nacre.

The above published descriptions by Lorenz are different from his own study of 1991, in which he demonstrated the differences between *B. amorimi* and *B. massieri* in a convincing manner. (Lorenz, 1991) These features include the convexity of the base in *B. amorimi as* opposed to the flat base of *B. massieri*, apart from the obvious difference in the shells' outlines (as well as multiple other features). The published opinions by Lorenz that only one Mozambican population exists, is not shared herein. (Lorenz 2017, Volume 1) The reasons include the following:

a) There are conchological differences between *B. fultoni amorimi* and *B. massieri* characterizing what appear to be separate populations, with only a few specimens that are not clearly assignable to either one. Specimens of *B. fultoni massieri* are more likely to be globular in shape than *B. amorimi*, and their extremities are quite rostrated. *B. fultoni amorimi* often have deltoidal appearances (See Table 1 and Plate 3).

b) There are also extremely heavy and calloused shells of *B. massieri* without the slightest indication of marginal protuberances characteristic in *B. amorimi*. At the same time, there are specimens of *B. amorimi* without dorsal granules characteristic of fully mature shells. Therefore, the extreme formation of callus is not an indication that *B. amorimi* is based on gerontic specimens as noted by Raybaudi.

c) The formulae (after Bridges & Lorenz 2013) indicate differences between *B. massieri* and *B. amorimi* (See Table 1).

d) It is not known where exactly the shells of *B. amorimi* as opposed to the vast amount of *B. massieri* were collected within the exact same range along the Mozambican coast. The two taxa might originate from geographically or bathymetrically-separated populations.

e) From all the information available, the population of deltoidal *B. amorimi* is from considerably deeper water than the comparatively abundant pyriform *B. massieri* from shallower water (*i.e.*, more than 250 meters as opposed to 75 to 125 meters, according to Raybaudi, 1990). There is a consensus that in direct developers such as the related Australian *Zoila*, bathymetric subspecies exist, whose conchological differences become more and more obvious with the different depths the shells originate from. (Lorenz, F.: Monograph of the Living *Zoila*, 2001, pages 13 to 14).

The subdivision of *B. massieri* versus the deeper water *B. amorimi* on the level of subspecies, therefore, is consistent with the taxonomic treatment of bathymetric populations in species of *Zoila*, as well as the South African

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Cypraeovula, and the Caribbean *Muracypraea*. In these cases, Lorenz postulates that: "juvenile intracapsular developers can travel long distances on pieces of host sponge torn off from the sea floor (phoretic dispersal)." This may account for the relatively shallower-located *B. massieri* versus deep water *B. amorimi*. (Lorenz, 2001. Monograph of the Living *Zoila*).

Recently, a series of outstanding specimens of South African *B. fultoni* were brought to the author's attention. These shells originated from a confined area towards the southern border of the species' distribution. They present an interesting parallel to the conchological differences noted between *B. f. amorimi* and *B. f. massieri*.

Barycypraea fultoni deltoidea
M.A. Mont, n. ssp.
(Plate 1, Figures A-D)

Description. The shell is rather large for the genus and extremely heavy. The outline is deltoidal, due to marginal protuberances protruding on either side of the posterior end. The dorsal profile is evenly rounded, with its highest point in the midsection. The posterior canal is broad and deeply cut, bordered by callus dorsally. The shell is evenly tapering from the protuberances towards the anterior extremity. The tips are shorter than the dome of the anterior end, which is separated from the dorsum by a shallow indentation. The anterior tips are thick and pointing downwards. The aperture is evenly narrow and slightly curved to the left. The labral teeth are dense, well-produced along the aperture, becoming slightly denser and thinner anteriorly. They extend onto the labrum as shallow ribs. The columellar teeth are sparse and coarse, with side interstices. The fossula is concave, slightly projecting, and separated from a produced terminal pleat, which reaches far into the aperture. The base is calloused and convex. The shell's ground color is grayish-white. The dorsum is framed by dark brown, leaving a cream-colored window, framed by darker brown-to-black irregular lines. These run parallel in some areas, and along a shallow longitudinal groove running from the anterior third to just above the extremity. The margins are grayish-cream and densely-spotted, with large, somewhat indistinct brown spots, which reach far onto the base and the labrum. These form depressions and indentations in the calloused areas and especially on the marginal protuberances. The teeth are orange along the aperture, enhanced by dark brown stripes labrally. The animal has a thin, transparent mantle with numerous fingerlike papillae, which may merge from the same spot on the mantle, forming structures resembling tiny bushes. The tips of the papillae are white. They extend onto the transparent siphon. The tentacles, eye stalks, and the foot are transparent grayish.

Type Material. Eleven live-collected and two dead specimens (one subfossil). All paratypes agree with the description of the holotype in a remarkably similar manner. Measurements enlisted length × width × height in millimeters (labral : columellar tooth count), [weight in grams].

Holotype:	62.6 × 45.3 × 31.3 (20:11) [59.6]
Paratype 1:	62.3 × 44.0 × 31.0 (19:11) [54.9]
Paratype 2:	65.5 × 44.5 × 31.6 (17:13) [56.9]
Paratype 3:	57.7 × 42.2 × 29.2 (18:11) [42.7]
Paratype 4:	64.5 × 44.1 × 31.6 (21:12) [57.1] fresh dead, not fully adult
Paratype 5:	62.3 × 42.2 × 31.2 (19:14) [50.9]
Paratype 6:	62.0 × 44.7 × 32.2 (19:10) subfossil
Paratype 7:	62.8 × 41.8 × 30.7 (19:12) [52.5]
Paratype 8:	66.6 × 45.2 × 31.8 (21:10) [57.9]
Paratype 9:	65.9 × 43.3 × 32.7 (21:14) [57.1]
Paratype 10:	62.0 × 41.8 × 31.2 (18:9) [49.7]
Paratype 11:	66.1 × 45.2 × 32.4 (20:12) [57.6]
Paratype 12:	68.5 × 46.3 × 34.9 (19:11) [66.6]

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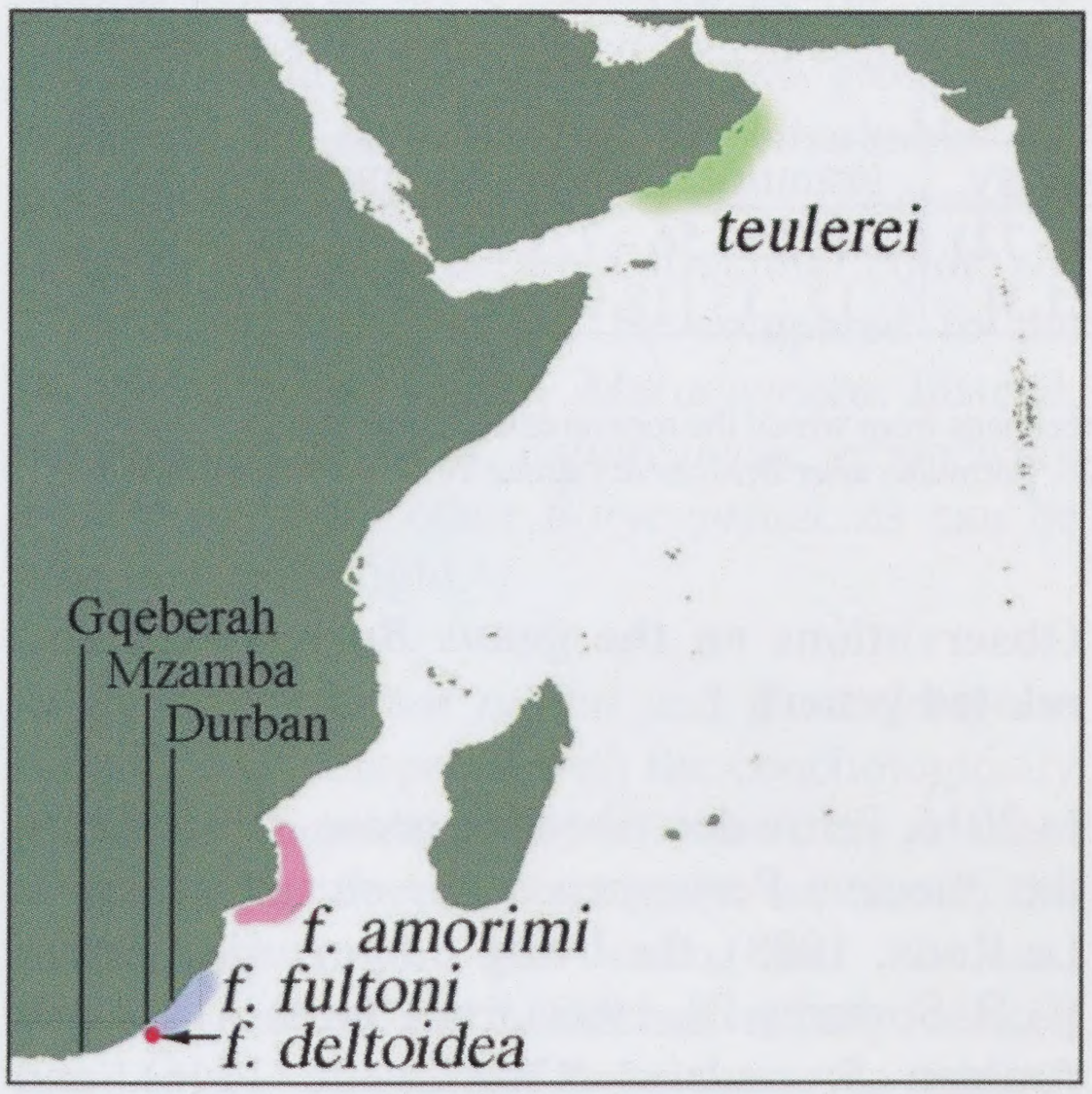
The types are placed in the Molluscan Science Foundation, Inc. ("MSF"), Baltimore, Maryland, USA. The Holotype bears MSF No. 11261, and Paratypes 1 to 6 bear MSF Nos. 11262-11267.

Type Locality, Distribution and Habitat. Most specimens of *B. fultoni deltoidea* n. ssp. were collected at 67 to 72 meters, on muddy sand with sparse sponge growth, offshore at the mouth of the Mzamba River, which is on the border between southern Kwa-Zulu-Natal and the northern Transkei (Type locality). A subfossil specimen (Paratype 6) with pronounced marginal protuberances was dredged in the same general area at 75 meters. A specimen conchologically identical to the recent findings was taken *ex pisces* in the 1960s and illustrated in Burgess (1970) (his Plate 4, A and $A_{1)}$. The exact provenance and depth of this shell are unknown (See Figure 3).



Map 1. Distributions of living *Barycypraea* (after Lorenz 2018, modified)

Etymology. *B. fultoni deltoidea* is named on ccount of its most outstanding feature; the deltoid shape.

DISCUSSION

B. fultoni deltoidea n. ssp. was collected at lower depths than the nominate *B. fultoni fultoni* found offshore in the northern Transkei to the north of Durban (See Map 1). Dead, subfossil specimens have been found as far south as East London. It lives at 67 to 72 meters on a similar sandy habitat and has repeatedly been found by dredging. Although variable in shape and coloration, no specimens with comparable marginal protuberances have ever been observed in the nominate *B. fultoni fultoni*. Specimens with an indication of such structures are known, and the holotype of *B. fultoni* is such a shell (See Figure 1). Further examples are shown on Plate 3. However, the deltoidal shape and the conspicuous marginal protuberances set all known specimens of *B. fultoni deltoidea* completely apart from its deeper water South African sister. This supports the subspecific (rather than the varietal) status. The indentation of the posterior canal on the dorsal view is shorter in *B. f. deltoidea*, and in *B. f. fultoni* the tips are more pointed and projecting. The specimens of *B. f. deltoidea* known to date are all quite large and exceptionally uniform, indicating that they belong to a confined genetically-isolated community.

Both South African taxa share the characteristics of the formation of the anterior extremity and the lesser number of columellar teeth, which separates these shells from the Mozambican *B. amorimi* and *massieri* among other less obvious features (See Table 1). The existence of a bathymetric-located subspecies with pronounced marginal callus accumulations in both areas inhabited by the species (Southern Africa and Mozambique) is an interesting parallel. However, one can ponder that the bathymetric occurrence of the "triangular" shape is the opposite.

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	fultoni fultoni	*fultoni deltoidea*	*fultoni amorimi*	*fultoni massieri*
Distribution	Kwa-Zulu-Natal to Northern Transkei	Northern Transkei	Southern Mozambique	Southern Mozambique
Depth range (meters)	90-150	67-72	> 250	75-125
Length (mm)	56-64 (61)	58-69 (64)	66-78 (70)	54-84 (72)
Width/length in %	60-68 (64)	66-73 (69)	71-76 (74)	64-69 (67)
height/length %	47-52 (50)	48-52 (50)	53-58 (56)	54-57 (55)
Columellar teeth	9-15 nl: 10	9-14 nl: 10	17-19 nl: 13	16-21 nl: 13
Mass ratio	17-21 (18.5)	20-22 (21.3)	18-20 (18.9)	14-19 (16.0)
Shape	narrow, pyriform	**deltoidal**	rhomboidal	inflated pyriform
Dorsal profile	low, rounded	low, rounded	high, humped	high, humped
Margins	Rounded	**Rounded**	Bent up, rounded	Low, less rounded
Base	Convex	Convex	Convex	Flat
Posterior tips	Pronounced	**Shorter**	Pronounced	Pronounced
Anterior tips	narrow, pointed	narrow, pointed	broad, spatulate	broad, spatulate
Basal spots	large, dense, dark	large, dense, dark	less dense, paler	less dense, paler
Enamel (mostly)	smooth, glossy	smooth, glossy	granulose, silky	granulose, silky
Formulae	61 (64 - 50 - 79) 15 : 10 [18.5]	**64 (69 - 50 - 72) 15 : 10 [21.3]**	70 (73 - 56 - 77) 17 : 13 [18.9]	72 (67 - 55 - 82) 15 : 13 [16.0]

Table 1. Comparison of the subspecies of *B. fultoni*. The number of specimens from which the measurements were derived are: *B. f. fultoni*: 17; *B. f. deltoidea*: 11; *B. f. amorimi*: 8; and *B. f. massieri*: 26. Formulae after Bridges & Lorenz 2013. Average values in brackets, nl: normalized average number of teeth.

While the subdivision of the species in South African (*B. fultoni*) versus a Mozambican (*B. amorimi*) subspecies is well-supported as well by molecular data, there remains an uncertainty concerning the two taxa from shallower water from the same general areas (*B. deltoidea* in South Africa and *B. massieri* in Mozambique). Their position either as bathymetric subspecies or bathymetric formae is an open question and for the time being, can remain as a matter of subjective interpretation.

Observations on the genus *Barycypraea* and related genera

In 2016, Fehse described the genus *Afrozoila* for the Pliocene *Barycypraea zietsmani* (Liltved & Le Roux, 1988), the living *Barycypraea fultoni* (G.B. Sowerby III, 1903) from South Africa, the Arabian *B. teulerei* (Cazenavette 1846), and various species from the Miocene of India and Indonesia. These are supposedly distinct from *Barycypraea*, which was based on *B. caputviperae* (Martin 1899) from the Indonesian Miocene. Fehse (2016) makes statements which deserve some further discussion.

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Lorenz briefly commented on *Afrozoila* in his 2017 Cowries Volume 1: "As the shell morphology of the Indonesian *B. caputviperae* group also resembles members of *Muracypraea*, Fehse (2016a) suggested a phylogenetic relationship between these genera. He erected the genus *Afrozoila* to accommodate morphologically less extreme fossils and two living species (*Barycypraea fultoni* and *B. teulerei*) that are interpreted as ancestral to the genus *Zoila*. To me, the morphological ties between the Indonesian fossils and the South African *B. fultoni* and its fossil precursor *B. zietsmani* are too obvious to follow this interpretation. First of all, the dorsal tubercles forming a window with a Maltese cross pattern is a feature that the living *B. fultoni* and the Indonesian Miocene *B. caputviperae* (Martin, 1899) and related taxa have in common. Secondly, the formation of the tubercles is quite similar between the South African Pliocene *B. zietsmani* and the *B. caputviperae* group. The similarity to *Muracypraea* is remarkable but superficial, as the marginal stripes observed in some *B. caputviperae* are a structural color, not a color pattern that can be compared to the striped margins of many *Muracypraea*. Instead, the margins of the *B. caputviperae* group were spotted as in all other *Barycypraea*, as can be seen under UV light."

When *Barycypraea fultoni* and *B. teulerei* are superficially compared with the conchologically extreme *B. caputviperae*, on which the concept of the genus *Barycypraea* must be based, the relationship might not seem that obvious. However, there are numerous closely related fossil species described from the same general area and stratigraphy as *B. caputviperae* which show a very similar shape, and a Maltese cross pattern visible even with the bare eye. The South African *B. zietsmani* from the Pliocene conchologically connects *B. fultoni* with the Indonesian Miocene *B. caputviperae* and its allies, as the Plates 5 and 6 herein demonstrate. Fehse related one of the less extreme relatives, *Barycypraea musissimilis* (Martin 1879) to *Muracypraea henekeni* (Gabb 1873) from the Caribbean Miocene.

A depression on the base above the columellar teeth found in both of these specimens is supposed to support this. A similar depression is also discernible in *B. zietsmani*, and it is absent from other Indonesian species directly related to *B. caputviperae*, and also, from most other fossil *Muracypraea* from the Caribbean (See Figure 4).

Figure 4. The depression above the columellar peristome. Left: *Muracypraea* sp. Miocene, Panama. Middle: *Barycypraea* cf. *caputviperae* Miocene, Indonesia. Right: *Barycypraea zietsmani* Pliocene, South Africa.

The margins of *Barycypraea caputviperae* and its relative *B. murissimilis* show a brilliant iridescent striping, which is a phenomenon caused by the microstructure of the shell in combination with a process of fossilization that enhances this feature. In living cowries, such a structure is well-visible in *Cypraea tigris* Linnaeus 1758 and *Lyncina vitellus* (Linnaeus 1758). In other species of *Lyncina* (*e.g. L. lynx* Linnaeus 1758), this structure is absent and therefore does not aid in generic characterization. To a lesser extent, it is found in *B. teulerei* and quite obviously is a feature found mainly in strongly calloused shells (See Figure 5). This pattern is not homologous with the striped coloration margins in derived forms

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of *Muracypraea,* in which the marginal pattern is primarily dark spotting, as can be seen in fossils as well as living specimens of the extant *Muracypraea mus tristensis* Petuch 1987. This dark spotting is also discernible in fossil and extant *Barycypraea*.

Figure 5. Top: Iridescent microstructure in **A, B=** *Barycypraea caputviperae*, **C=** *Lyncinia vitellus*, **D=** *Cypraea tigris,* and **E=** *B. teulerei*. Bottom: Marginal pigmentation in **F=** *Muracypraea mus mus,* and **G=** *M. mus tristensis*. Not to scale. Explanations in the text.

Aspects of the anterior extremity shown in Figure 3 show that this feature can not be used to distinguish between *Barycypraea* and the "*Afrocypraea*" group, and the spatulate anterior extremity of most *Muracypraea* does not resemble that of *B. caputviperae* at all. Instead, the peculiar split callus-ridge on the center of the dorsum (See Plate 5: L, M) is only found in the *B. caputviperae* group and *B. zietsmani*, which indicates a close relationship between them.

Fehse's statement that "*mus* and *fultoni* are not related" is in my opinion a misinterpretation of the molecular data. The phylogram (See Figure 7) merely shows that the relationship between *Barycypraea* and *Zoila* is closer than to *Muracypraea*, but all three genera merge from an ancient lineage which also gave rise to *Cypraea* and the group of *Mauritia*, *Leporicypraea*, and *Macrocypraea*. What can be said is that the Caribbean *Muracypraea* split off that lineage at an earlier date than *Barycypraea* and *Zoila,* but this does not denote that it is "not related" to *B. fultoni* and *B. teulerei*. Given the fossil record, we can assume that the separation between these groups could have happened in the Oligocene, and *Muracypraea* has always been restricted to Central and Northern America. An interesting observation on the side is that the animals of *Cypraea tigris*, *Muracypraea mus*, and *Barycypraea fultoni* have in common is that their papillae are finger-like, with a conspicuous white tip (See Figure 14).

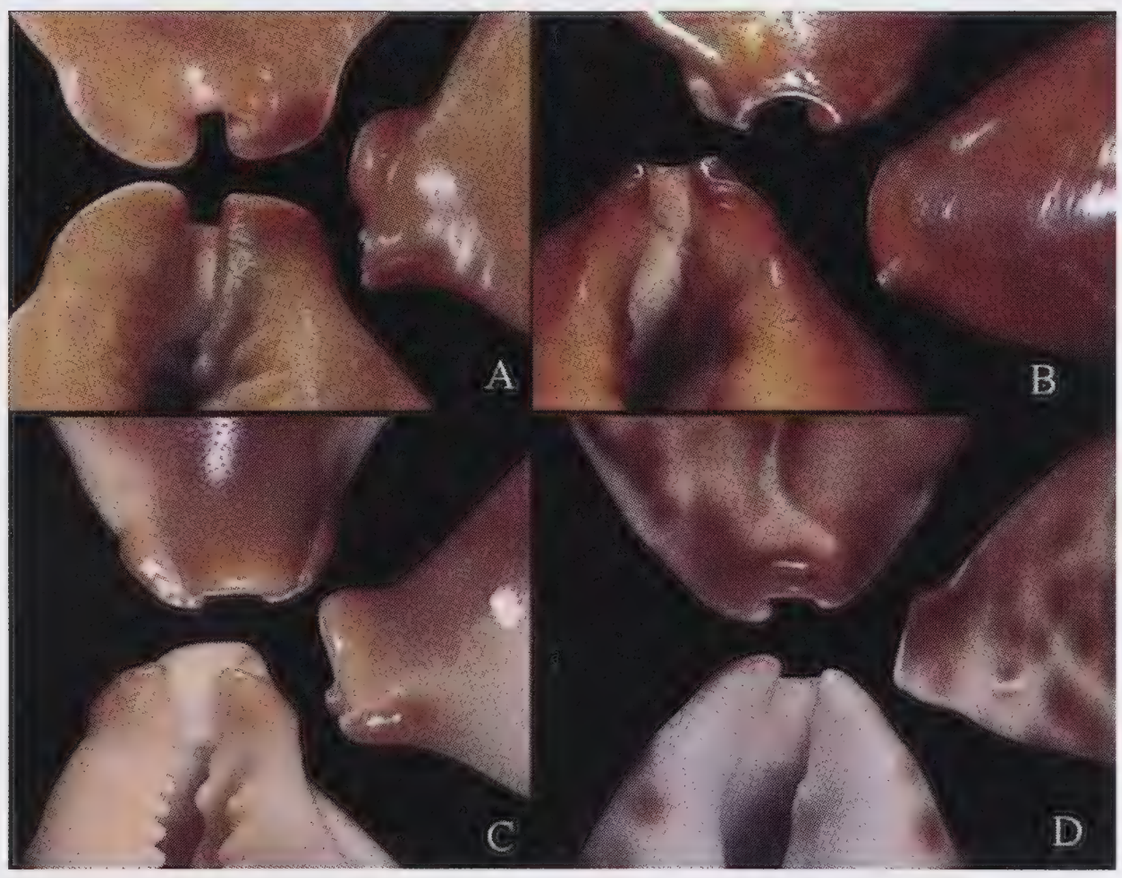

Figure 6. Different aspects of the anterior extremity.
A= *Muracypraea* sp., Miocene, Dominican Republic;
B= *Barycypraea caputviperae*, Miocene, Indonesia;
C= *Barycypraea fultoni amorimi*, recent, Mozambique.
D= *Barycypraea teulerei,* recent, Oman.

The supposed generic division of the Indonesian Miocene fossils related to *B. caputviperae* (*Barycypraea sensu stricto*) from certain Miocene fossils and the extant *B. fultoni* and *B. teulerei* (*Afrozoila* according to Fehse, 2016) is

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based on conchological features. The dilemma is only that the differences between *B. teulerei* and *B. fultoni* are certainly greater than between *B. fultoni*, the ancestral *B. zietsmani,* and the *B. caputviperae* group. In *B. teulerei*, there is no distinct dentition, the fossula region differs from all other taxa (except the Pliocene *B. zietsmani* to a certain extent), and the dorsal pattern shows no indication of an exposed median area or a Maltese cross pattern (See Plate 9).

Figure 7. Molecular phylogram of *Barycypraea* and related genera, after Meyer (2004, modified).

The recently described *Barycypraea iungo* Aiken & Seccombe, 2022 from Richards Bay is clearly linked to *B. zietsmani* from further south. Its exact stratigraphy is unknown, but assumed to be of similar age (Pleistocene of the Alexandria formation). The remarkable, well-preserved shell resembles an inflated *B. zietsmani,* but shows distinct columellar dentition, and its position as a conchological link between the fossil South African lineage and the living *B. fultoni* is obvious and its name well-chosen (See Figure 17). The authors also note a similarity to the Indonesian *B. murissimilis*. In concluding, if a distinction of *Afrozoila* from *Barycypraea* was pursued, then *B. teulerei* would require a separate genus, based on the aberrant conchology of that species. The molecular data, on the other hand, shows *B. fultoni* and *B. teulerei* to be sisters. What can be said is that none of the conchological features we can derive from the fossil and the living record is suitable for a distinction of the Miocene Indonesian and the Pliocene to recent Western species complexes.

Figure 8. *Barycypraea iungo* Aiken & Seccombe 2022. (60 mm) Richardsbay, Kwa-Zulu Natal, South Africa, Pleistocene. MSA-Mol 0P2009/T4560.

The protoconch of *Barycypraea zietsmani* indicates intracapsular development, but morphologically, it is quite different from that of *B. fultoni*, being pointed instead of sunken, and much smaller (*i.e.,* 0.15 versus 0.25 millimeters in *B. fultoni*). But although more similar in size, it does not resemble the protoconch of *B. teulerei* in shape (See Figure 9). A scenario where *Muracypraea* is basically synonymous with *Barycypraea* would presuppose a westward migration from Central America across the Pacific. For cowries, only few species have migrated eastward across the Pacific to the Panamic province (*e.g.*, *Luria isabella*, *L. isabellamexicana, Talostolida pellucens,* and *T. p. panamensis*). However, this happened approximately five million years later, when prevailing ocean currents had changed after the closure of the isthmus of Panama.

Also, all cowry species that reached to the western coast of America from the Central Pacific are known to have a long planktonic phase, allowing the eastward travel during phases of exceptional surface currents from their western distributions, and only after geographically, "stepping stones" such as the

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Hawaiian and Galapagos Islands and Clipperton Atoll had formed. The same could not have happened during the Miocene, in the opposite direction, and not within groups that had by then given up planktonic development.

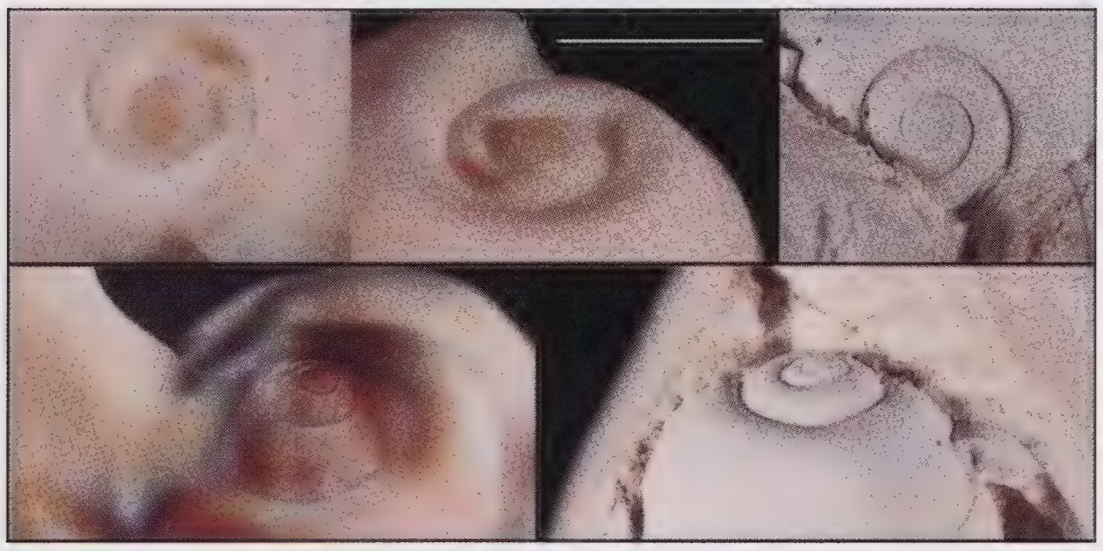

Figure 9. Protoconchs of *B. fultoni fultoni* (top left and middle), *B. teulerei* (bottom left), and *B. zietsmani* (top and bottom right). Scale = 1 centimeter.

Figure 10. Cowries of the Eocene that might be forefathers of *Muracypraea* and *Barycypraea*. Are the similarities to *Barycypraea* (*i.e.,* tubercles and callousities, reduced dentition), convergent developments, or an indication for relationship? Left: *Gisortia tuberculosa* (Duclos 1825), (117 mm) Ypresian Eocene, Gan, France. Right: *Vicetia roncana* (De Gregorio 1896), (106 mm), Lutetian Eocene, Dudar, Hungary.

The conchological similarities between the fossil *Barycypraea*, *Muracypraea*, and the once widespread Eocene *Gisortia* and *Vicetia* suggest that there could be a common ancestry that lies much further back (See Figure 9). A problem in this hypothesis arises from the lack of sufficient fossil records dating from the Oligocene epoch (a gap of approximately 10 million years), or perhaps, we do not recognize them as what they might have been, as the state of preservation of the few candidates for continuing the lineages is too poor to allow exact generic assignments. Apart from fossil and living species of *Muracypraea* and *Barycypraea* (See Figure 7), and the "monsters of the Eocene of the genera *Gisortia* (see Figure 11 and *Vicetia)*, there have been very few examples of cowries with prominent tubercles (with the popular exception of *Monetaria moneta*).

The features of marginal and dorsal tubercles framing a window (often decorated by a Maltese-cross pattern) could be a convergent development inherent to all cowries, which may be switched on and off within genera or even species. An example is *Monetaria moneta* (Linnaeus 1758), of which there are smooth and

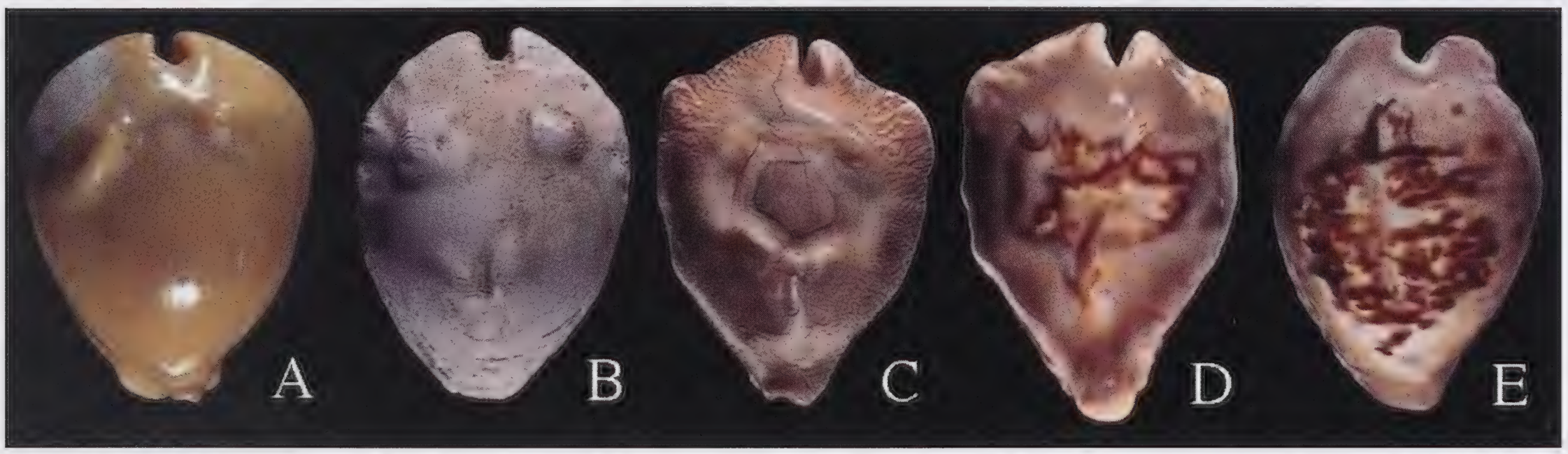

Figure 11. A= *Muracypraea* cf. *henekeni* (52 mm) Miocene, Dominican Republic; **B**= *Barycypraea zietsmani* (51 mm) Pliocene, South Africa; **C**= *Barycypraea* cf. *caputviperae* (45 mm) Miocene, Java, Indonesia; **D**= *Barycypraea fultoni deltoidea* (62 mm) Recent, South Africa; **E**= *Barycypraea teulerei* (50 mm) Recent, Oman.

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heavily tuberculose forms, and forms in which a distinct orange ring visually enhances the dorsal window encircled by callus and tubercles. Such forms do not occur throughout the range of the species, but predominantly in the Central Pacific and on isolated Atolls (See Figure 12).

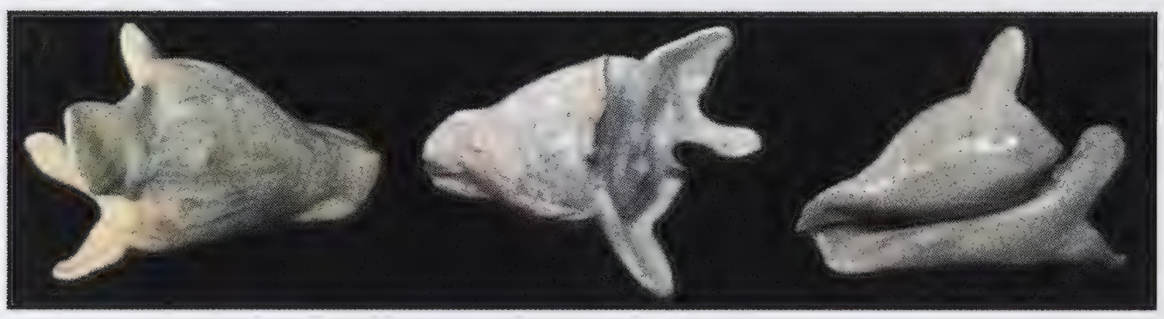

Figure 12. *Gisortia megaloptera,* 160 mm (Miocene)

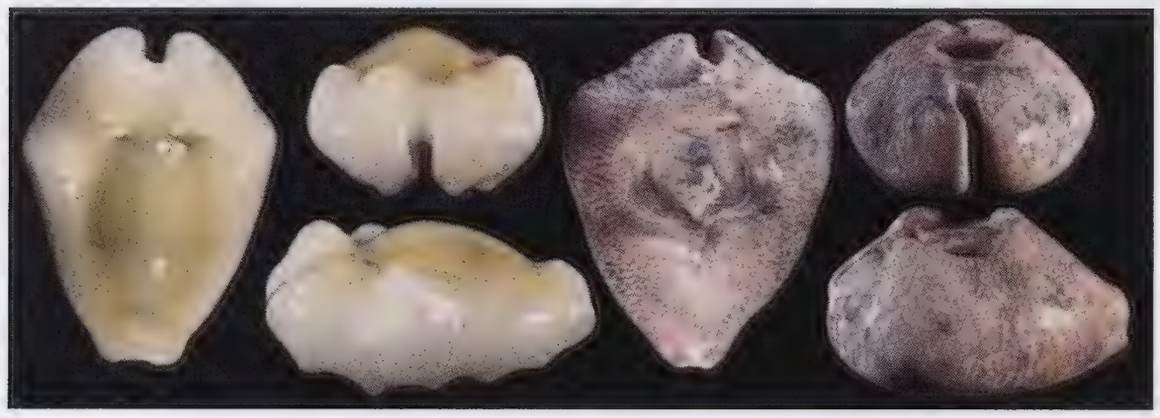

Figure 13. Convergent development of tubercles. Left: *Monetaria moneta* (14 mm) Tahiti, right: *Barycypraea* cf *caputviperae* (48 mm) Java, Indonesia, Miocene.

Is intracapsular development an evolutionary cul-de-sac and not reversible within a lineage? Lorenz (2017) stated "the morphological modifications required from planktonic to intracapsular development are minimal (...) with few or no phylogenetic implications" to which he recently added "and is most probably reversible" (Lorenz, personal communication 2018). The dynamics by which cowries distribute, also over long distances, might include the capacity of switching back and forth between developmental modes to adapt to local conditions within a relatively short period of evolution: to low water temperature, or to strong prevailing ocean currents. In the intracapsular developers, the vertical dispersal of populations seems dependent on ocean currents, whereas, the horizontal dispersal over different bathymetric levels may require additional factors.

In planktonic developers, bathymetric boundaries do not exist as larvae may drop to deep water from the sea surface, the chances of survival are just much lower than in intracapsular developers. In this regard, they "play it safe."

An interesting observation, independent from the above, relates to one of the oldest known true cowries, *Afrocypraea chubbi* (Rennie 1930). This fascinating and mysterious cowry, completely covered with prominent pustules, had a large paucispiral protoconch suggesting an intracapsular developer (See Figure 13). It was discovered in the Campanian Cretaceous deposits along the beach of the Mzamba River, near the type locality of *B. fultoni deltoidea*.

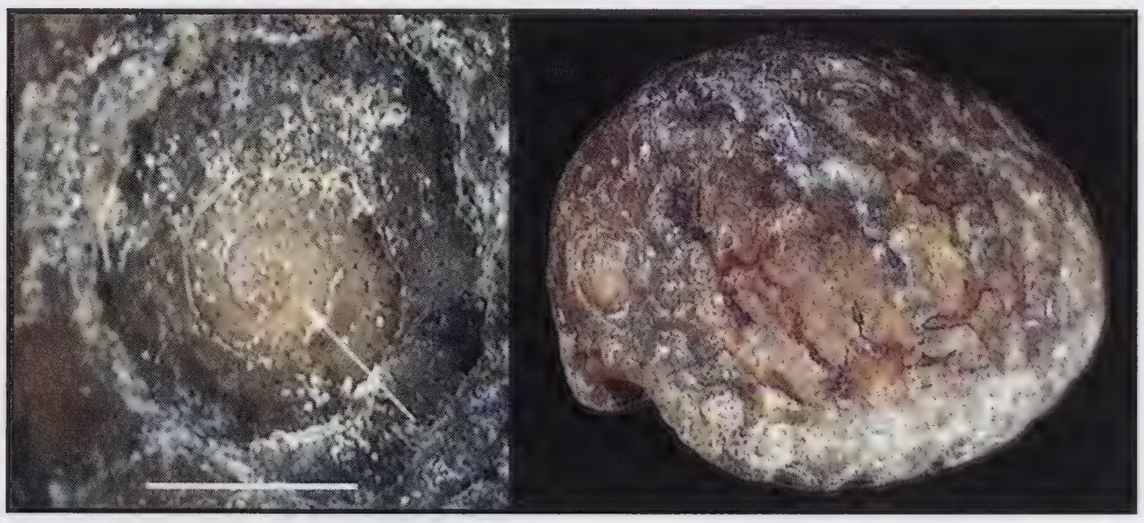

Figure 14. *Afrocypraea chubbi* (80 mm), Mzamba, Northern Transkei, Cretaceous (Campanian, approximately 72 million years old). Left: detail of the spire, arrow pointing at the paucispiral protoconch indicating intracapsular development. Scale = 1 centimeter.

Figure 15. Similar papillae in the animals of *Cypraea tigris* (left), *Muracypraea mus* (middle, photo Gary Schmeltz), and *Barycypraea fultoni*. Courtesy Felix Lorenz. Explanations in the text.

Conclusion. The delta-shaped *Barycypraea fultoni deltoidea,* was described as a new subspecies. The separation of the two distinct Mozambican *B. fultoni* populations has been

clarified. A further description of the four *B. fultoni* taxa have been compared and contrasted. Various observations about *Barycypraea* and related genera have been described in detail. *Afrocypraea chubbi*, found in Cretaceous deposits near locality of *B. fultoni deltoidea*, was described.

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Many thanks to Dr. Felix Lorenz for useful suggestions and photos. Thanks are also given to Elma Mai, the Fraser family, Wolfgang Grulke, and William R. Liltved. Tremendous thanks to Dr. Daniel Hameed for formating and editing the preparation of this article.

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Plate 1. *Barycypraea fultoni deltoidea* n. ssp. All from Mzamba, Northern Transkei, at 67-72 meters. **A**= Holotype (62.6 mm) (MSF No, 11261; **B**= Paratype 1 (62.3 mm) (MSF No. 11262); **C**= Paratype 3 (57.7 mm) (MSF Np. 11263); **D**= Paratype 2 (65.5 mm) (MSF No. 11264).

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Plate 2. *Barycypraea fultoni fultoni* (Sowerby III 1903). Variations from Kwa-Zulu Natal, South Africa. **A**= 56 mm. Durban area, Kwa-Zulu Natal, ex pisce; **B**= 59 mm. Hibberdene, Kwa-Zulu Natal, at 125 meters; **C-E**= 59-64 mm. Pennington, Kwa-Zulu Natal, at 100-120 meters; **F, G**= 56-57 mm. Southern Kwa-Zulu Natal, at 100-150 meters; **H, I**= 61-64 mm. Umkomaas, Kwa-Zulu Natal, at 90-105 meters.

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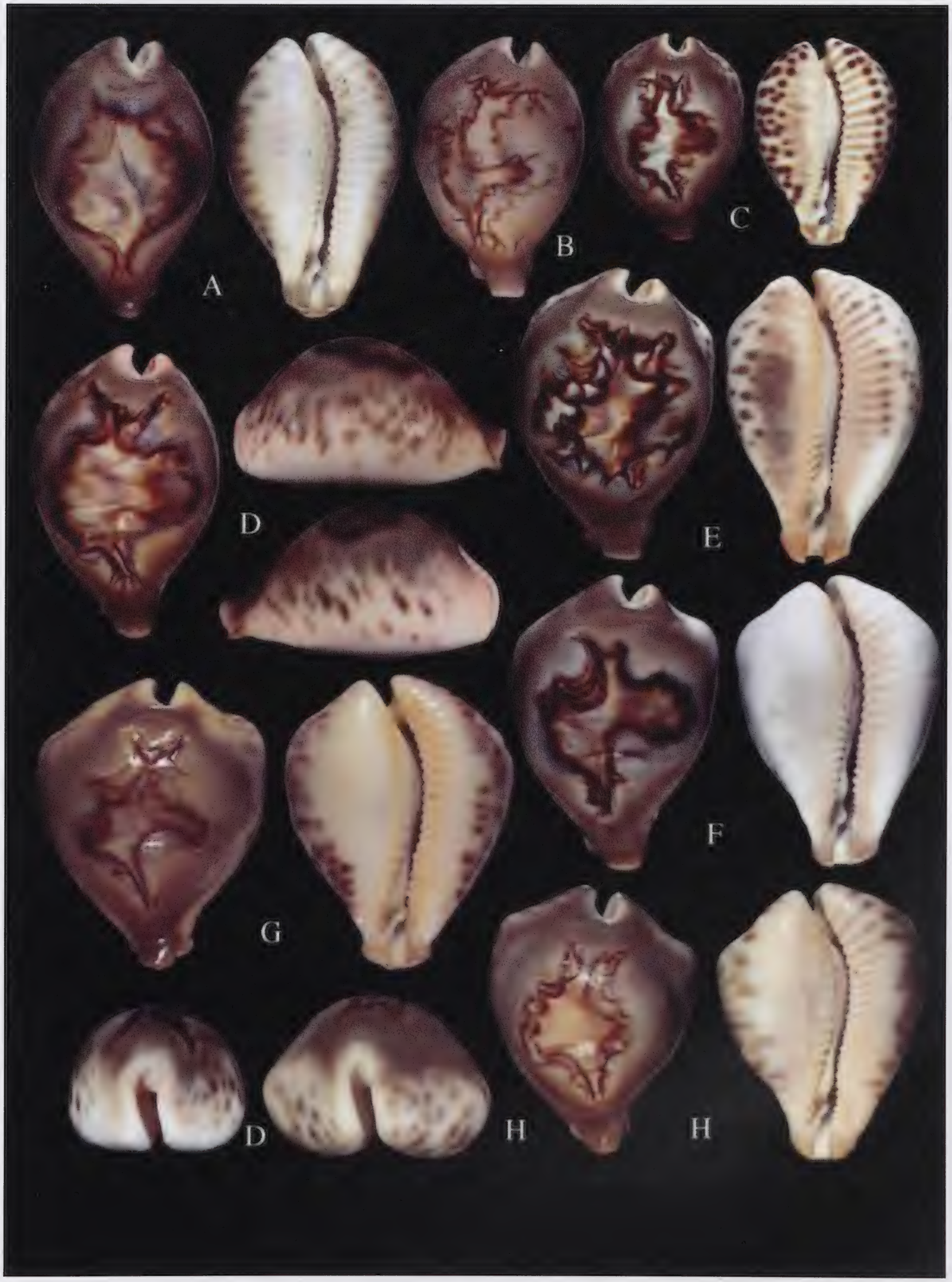

Plate 3. *Barycypraea fultoni massieri* Lorenz 1991. **A-D**= 55-75 mm. Southern Mozambique, at 75 to 125 meters; *Barycypraea fultoni amorimi* Raybaudi 1990 **E-H**= 68-77 mm. Southern Mozambique, at 150-250 meters.

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Plate 4. *Barycypraea zietsmani* Liltved & Le Roux 1988 (47-65 mm) Pliocene (Alexandria Formation) near Coega, north of Gqeberha (formerly Port Elizabeth), South Africa.

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Plate 5. A, B= *Muracypraea woodringi* Landau & Groves 2011 (38-52 mm), Late Miocene, Cativa, Colon, Panama; **C**= *Muracypraea henekeni* (Gabb 1873) (52 mm) Pliocene. Gurabo River, Dominican Republic; **D**= *Barycypraea murissimilis* (Martin 1879) (44 mm) Miocene, Nyalindung, Java, Indonesia; **E**= *Barycypraea beberkiriana* (Martin 1879) Miocene, Nyalindung, Java, Indonesia; **F**= *Barycypraea caputviperae* (Martin 1899) (34 mm) Miocene, Nyalindung, Java, Indonesia; **G**= *Barycypraea quadrinodosa* Fehse 2012 (32 mm) Miocene, Nyalindung, Java, Indonesia. Note the well-visible maltese-cross pattern; **H, I**= *Barycypraea caputviperae* (Martin 1899) (37-41 mm) Miocene, Nyalindung, Java, Indonesia; **J, K**= *Barycypraea zietsmani* Liltved & Le Roux 1988 (47-53 mm) Pliocene (Alexandria Formation) near Coega, north of Gqeberha (formerly Port Elizabeth), South Africa. Photos taken under UV light and inversed to display the color pattern; **L, M**= top: *caputviperae*, bottom: *zietsmani*, arrow pointing at the dorsal callus ridge these species had in common.

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Plate 6. A-C= *Barycypraea teulerei* (Cazenavette 1846) (43-48 mm) Masirah Island, Oman, intertidally. The shell morphology of this strange cowry does not resemble any other living or fossil species, yet the molecules show it as closest related to *fultoni;* **D**= *Muracypraea mus mus* (Linnaeus 1758) (41 mm) Amuay Bay, Venezuela, shallow water; **E**= *Muracypraea mus bicornis* (Sowerby II 1870) (52 mm) Paraguana Peninsula, Venezuela, at 40 meters; **F**= *Muracypraea mus bicornis* f. *tristensis* Petuch 1987 (54 mm) Cabo de La Vela, Colombia, at 100-120 meters; **G**= *Muracypraea mus bicornis* f. *donmoorei* Petuch 1979 (48 mm) Goajira Peninsula, Colombia, at 60-80 meters; **H**= *Muracypraea mus bicornis* f. *insolatia* Lorenz 2017 (48 mm) Paraguana Peninsula, Venezuela, at 60 meters; The variability of the dorsal tubercles, the dentition, the formation of the anterior extremity, and the color pattern is remarkable. Molecular data reveals that all the living members of *Muracypraea* are very closely related.

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Description of Three New *Bistolida* Species (Gastropoda: Cypraeidae) from Mozambique and KwaZulu-Natal, South Africa

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ABSTRACT The *Bistolida* of southern Mozambique and KwaZulu-Natal South Africa is revised with two species having new combinations *B. uvongoensis* and *B. jangamoensis,* dealt here as full species. The study of the southern Mozambique and northern KwaZulu-Natal revealed one new species, described here as *B. kosibayensis* n. sp., whereas the study on the southern KwaZulu-Natal shells revealed two new species, *B. ronniewatti* n. sp. and *B. groenewaldi* n. sp.

KEYWORDS Cypraeidae, *Bistolida,* Mozambique, KwaZulu-Natal, South Africa

INTRODUCTION

The shells presented in the *Bistolida* genus is always a striking presentation in any book, described as short-cylindrical to elongate-oval shells, umbilicate spire, with rather strong but often numerous teeth which often extend across the base (Lorenz & Hubert 2000, Lorenz 2002, Lorenz 2017). Dorsum usually bluish tinted with a dark blotch or patches and fine spots (Lorenz & Hubert 2000, Lorenz 2002, Lorenz 2017). The *Bistolida* is usually grouped into several species with many subspecies (Burgess 1985, Lorenz & Hubert 2000, Lorenz 2017, Lorenz 2018), with each reference placing subspecies even under different species names which creates a lot of confusion. *Bistolida uvongoensis* Massier, 2004 is one of those that was firstly described as a subspecies of *B. stolida* (Massier, 2004), found in some private collections as *B. clavicola uvongoensis,* and more recently cited in Lorenz (2017, 2018) as *B. diauges uvongoensis*. *Bistolida uvongoensis* is different enough from the other species within the *Bistolida* genus to deserve full species status, thus will be dealt as such as a new combination.

Bistolida uvongoensis is closely related, but distinct from its closest congeners being *B. clavicola* Lorenz, 1998 (Plate 2 Q-T), *B. diauges* (Melvill, 1888) (Plate 2 I-L), and *B. jangamoensis* Aiken & Seccombe, 2022. *Bistolida jangamoensis* was originally described as a subspecies of *B. clavicola,* but are treated here as a full species in a new combination, as its shell morphological characteristics are sufficiently different from its closest congeners. It's already well established that *B. diauges* and *B. clavicola* and other species from northern Mozambique and northern East-African countries, and Madagascar are different from South African and southern Mozambique species: *B. uvongoensis* and *B. jangamoensis* (Massier 2004, Lorenz 2017, Lorenz 2018, Aiken & Seccombe 2022) (Figure 1). The study of the southern Mozambique and northern KwaZulu-Natal revealed one new species, described here as *B. kosibayensis* n. sp., whereas closer study on the southern KwaZulu-Natal shells revealed two new species, *B. ronniewatti* n. sp. and *B. groenewaldi* n. sp.

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Figure 1. Main locality points where the South African and Mozambique *Bistolida* species occur (Map compiled by the author, 2022).

METHODOLOGY

The material studied comprises of 65 shells, beach collected, dived and trawled off the KwaZulu-Natal and Mozambique coast, from several private collections and the Natal Museum, South Africa (NMSA).

Main shell morphological features were used during this study to differentiate the new species from the closest congeners within the genus *Bistolida*. Detailed outline of the aperture side is compared along with aperture shape as the main differentiating factor between the species (Table 1 and 2, Figure 4). Measurements were taken of the maximum shell length, maximum diameter (width) and maximum height (Table 3).

The terminology used within this description:

The following measurements were taken for each specimen studied:

- SL – maximum shell length (mm)
- MD – maximum diameter / width (mm)
- H – maximum height (mm)

The formulas and analysis of Bridges & Lorenz (2013) were investigated and was found that the differences between the species are so small that it becomes insignificant to use as a differentiating factor.

The general shell morphological characters and terminology used in the description is illustrated in Figure 2.

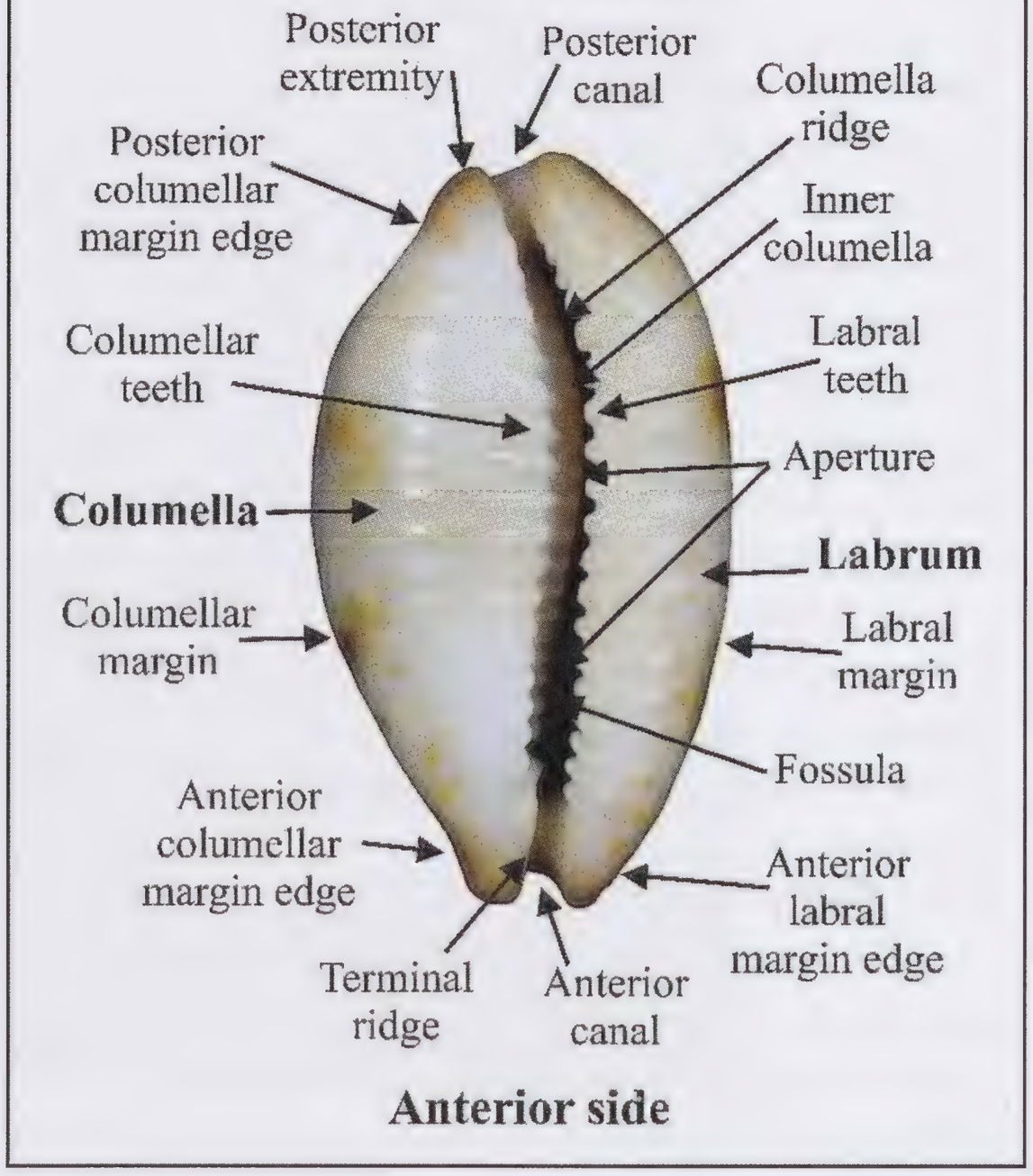

Figure 2. Shell morphological characters and terms.

Photos not specifically referenced were taken by the lead author: S.G. Veldsman.

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SYSTEMATICS

Phylum Mollusca Linnaeus,1758
Class Gastropoda Cuvier, 1795
Subclass Caenogastropoda Cox, 1960
Order Littorinimorpha Golikov & Starobogatov, 1975
Superfamily Cypraeoidea Rafinesque, 1815
Family Cypraeidae Rafinesque, 1815
Subfamily Erroneinae Schilder, 1927
Tribe Bistolidini Meyer, 2003
Genus *Bistolida* Cossmann, 1920

Bistolida uvongoensis Massier, 2004
(Plates 1 A-D, 3 A-F)

Revised Description. Shell small (22-31 mm). Profile elongate-oval, small umbilicate spire. Dorsal profile slightly rounded to flat, the highest point is about one third from the posterior end. Labrum margin smooth to slightly irregular, curved on posterior side, small section straight at the center, curved from center to anterior side. Columella margin oval, posterior columellar margin edge angling in moderately, ending with a sharp curve at the posterior extremity, anterior columellar margin edge curving in moderately. Base flat with columella only slightly bulbous. Aperture, relatively straight at center, opening moderately narrow to narrow, posterior side curving slightly, opening moderately narrow to narrow, anterior side straight and moderately opening. Labral teeth moderately large and extending across labrum smoothing out towards the margin, 17-20 number of teeth. Columellar teeth small, posterior side teeth faint, extending across columella smoothing out towards margin, center teeth shortening, anterior side teeth only on aperture edge with columella being smooth. Small teeth present on columella ridge and fossula.

The base color is greenish-beige with a tint of orange, consisting of five broad bands, posterior, center and anterior bands dark, with the other two being lighter colored. One large slightly perforated brown blotch present on the center of the dorsum. Two dark brown blotches on the labrum and two on the columellar margin. Both margins are covered with very fine brown spots, with the fine spots extending sparsely over the dorsum (only visible in fresh specimens). Both extremities have darker brown coloration on both sides. The base is light cream to off-white, no staining visible on the teeth.

Type. The holotype of *Bistolida uvongoensis* Massier, 2004, 29.6 x 16.7 mm, Haus der Natur – Cismar, HNC 62712 (Plate 1 A-D).

Type locality. Uvongo/Shelly Beach, southern KwaZulu-Natal, South Africa.

Distribution. Specimens were recorded off localities such as Umkomaas, Scottburgh, Park Rynie, Pumula, Melville and Shelly Beach, southern KwaZulu-Natal, South Africa. Specimens studied were either beach collected or scuba to depths of 28 m.

Bistolida ronniewatti S.G. Veldsman & J.H. Veldsman, new species
(Plates 1 E-H, 3 M-R)

Description. Shell small (22-31 mm). Profile elongate-cylindrical, small umbilicate spire. Dorsal profile slightly rounded to flat, the highest point is about one third from the posterior end. Labrum margin smooth to slightly irregular, curved on posterior side, largest portion of the center section straight, curving in sharply at anterior side. Columella margin slightly oval, posterior columellar margin edge curving in a rounded manner high on profile, angling in sharply at the posterior extremity, anterior columellar margin edge

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curving in moderately. Base moderately flat, labrum slightly rounded, columella slightly bulbous. Aperture, slightly curved at center and opening wide, posterior side curving strongly, opening wide, anterior side straight and opening very wide. Labral teeth large and extending across labrum smoothing out towards the margin, 18-20 number of teeth. Columellar teeth small, posterior side and center teeth faint extending just over the columella ridge, anterior side teeth only on aperture edge with columella being smooth. Small teeth present on columella ridge and fossula.

The base color is greenish-beige with a tint of orange, consisting of five broad bands, posterior, center and anterior bands dark, with the other two being lighter colored. One large brown blotch, with a split mid-dorsum on the center of the dorsum, sometimes fingering out. Two dark brown blotches on the labrum and two on the columellar margin, slightly extending onto the dorsum. Both margins are covered with very sparse fine brown spots, with a few to no spots on the dorsum (only visible in fresh specimens). Both extremities have darker brown coloration on both sides. The base is light cream to off-white, no staining visible on the teeth.

Type locality. Mzamba, northern Eastern Cape / border of southern KwaZulu-Natal, South Africa.

Distribution. Specimens were recorded off localities such as Addington dredging's (Durban), Umkomaas, Sezela, Widenham, Umdloti, Aliwal Shoal, Margate, Mzamba, southern KwaZulu-Natal, South Africa. Specimens studied were beach collected, scuba to depths of 40 m.

Type material.

Holotype: 26.85 x 15.74 mm (Plate 1 E-H); Beach collected, Mzamba, northern Eastern Cape / border of southern KwaZulu-Natal; Coll. Natal Museum, Pietermaritzburg, South Africa: NMSA-Mol. P2312/T4595, donated by the Veldsmans.

Paratype 1: 30.97 x 16.49 mm (Plate 1 M-P); Live taken, Margate, southern KwaZulu-Natal; Veldsman Collection.

Paratype 2: 28.49 x 16.13 mm (Plate 1 Q-R); Beach collected, Mzamba, northern Eastern Cape / border of southern KwaZulu-Natal, southern KwaZulu-Natal; Veldsman Collection.

Paratype 3: 27.62 x 15.22 mm; Beach collected – dredging material, Addington Beach, southern KwaZulu-Natal; Veldsman Collection.

Paratype 4: 24.51 x 14.34 mm; Beach collected, Umdloti, southern KwaZulu-Natal; Veldsman Collection.

Paratype 5: 22.62 x 13.12 mm; Scuba 35-40 m, Aliwal Shoal, southern KwaZulu-Natal; Veldsman Collection.

Paratype 6: 22.44 x 13.27 mm; Beach collected – dredging material, Addington Beach, southern KwaZulu-Natal; Veldsman Collection.

Paratype 7: 29.83 x 16.45 mm; Beach collected, Sezela, southern KwaZulu-Natal; NMSA-Mol. 4812/T4590.

Paratype 8: 28.44 x 16.25 mm; Beach collected, Umkomaas, southern KwaZulu-Natal; NMSA-Mol. 754/T4592.

Paratype 9: 28.94 x 15.58 mm; Beach collected, Umkomaas, southern

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KwaZulu-Natal; NMSA-Mol. 4807.

Paratype 10: 27.16 x 15.93 mm; Beach collected, KwaZulu-Natal; NMSA-Mol. A4632/T4589.

Paratype 11: 21.58 x 12.26 mm; Beach collected, Wydenham, southern KwaZulu-Natal; NMSA-Mol. B1916/T4591.

Paratype 12: 26.64 x 15.64 mm; Beach collected, Mzamba, northern Eastern Cape / border of southern KwaZulu-Natal; H. Smit Collection.

Paratype 13: 28.88 x 16.40 mm; Beach collected, southern KwaZulu-Natal; Veldsman Collection.

Paratype 14: 26.03 x 14.77 mm; Beach collected, southern KwaZulu-Natal; Veldsman Collection.

Etymology. This species is named for Ronnie Watt, friend of the authors and the person who started the research on the *Bistolida* from South Africa that formed the background of this research.

Bistolida groenewaldi S.G. Veldsman & J.H. Veldsman, new species
(Plates 1 I-L, 3 G-L)

Description. Shell small (22-27 mm). Profile oval, small umbilicate spire. Dorsal profile rounded, slightly flattish on top, the highest point is about one third from the posterior end. Labrum margin smooth to slightly irregular, curved on posterior side, largest portion of the center section curved all the way to the anterior side. Columella margin oval, posterior columellar margin edge curving in a rounded manner high on profile, angling in sharply at the posterior extremity, anterior columellar margin edge almost stepped, curving in moderately at the end. Base moderately flat, labrum flat to slightly rounded, columella bulbous. Aperture, slightly curved at center and narrow, curving strongly towards posterior side, staying narrow, center to anterior side opening very wide, curving strongly. Two small crenulations on posterior side of labrum, usually not visible and covered by callus. Labral teeth large and extending across labrum smoothing out towards the margin, 18-19 number of teeth. Columellar teeth small, posterior side and center teeth faint extending just over the columella ridge, smoothing out towards the center of the columella, anterior side teeth only on aperture edge with columella being smooth. Small teeth present on columella ridge and fossula.

The base color is greenish-beige with a tint of orange, consisting of five broad bands, posterior, center and anterior bands dark, with the other two being lighter colored. One large brown fragmented blotch, split mid-dorsum just off center of the dorsum, labrum side, fingering towards markings on margins. Two dark brown blotches on the labrum and two on the columellar margin, slightly extending onto the dorsum. Both margins are covered with very sparse fine brown spots, with a few to no spots on the dorsum (only visible in fresh specimens). Both extremities have darker brown coloration on both sides. The base is light cream to off-white, no staining visible on the teeth.

Type locality. Beach collected, Pumula, southern KwaZulu-Natal, South Africa.

Distribution. Specimens were recorded off localities such as Addington dredging's (Durban), Durban Harbor, Tongaat, Umdloti, Aliwal Shoal, Park Rynie, Pumula, Port Shepstone, southern KwaZulu-Natal, South Africa. Specimens studied beach collected, scuba to depths of 40 m or dredged.

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Type material.

Holotype: 27.72 x 15.73 mm (Plate 1 I-L); Beach collected, Pumula, southern KwaZulu-Natal; Coll. Natal Museum, Pietermaritzburg, South Africa: NMSA-Mol. P2311/T4594, donated by Anton Groenewald.

Paratype 1: 24.35 x 14.64 mm (Plate 3 G-H); Scuba 25m, Park Rynie, southern KwaZulu-Natal; Veldsman Collection.

Paratype 2: 24.05 x 13.94 mm; Scuba 25m, Park Rynie, southern KwaZulu-Natal; Veldsman Collection (ex. Paratype 2 of *B. uvongoensis*).

Paratype 3: 25.33 x 15.06 m; Scuba 35-40 m, Aliwal Shoal, southern KwaZulu-Natal; Veldsman Collection.

Paratype 4: 25.35 x 15.14 mm; Beach collected, southern KwaZulu-Natal; R. Aiken Collection.

Paratype 5: 24.94 x 14.93 mm; Dredged, Durban Harbour, KwaZulu-Natal; Veldsman Collection.

Paratype 6: 25.27 x 14.50 mm; Beach collected – dredging material, Addington Beach, southern KwaZulu-Natal; Veldsman Collection.

Paratype 7: 25.31 x 14.84 mm; Beach collected, Pumula, southern KwaZulu-Natal; L. Swart Collection.

Paratype 8: 23.77 x 14.03 mm; Beach collected, southern KwaZulu-Natal; R. Aiken Collection.

Paratype 9: 22.84 x 13.89 mm; Beach collected, Tongaat, southern KwaZulu-Natal; NMSA-Mol. 4808/T4581.

Paratype 10: 28.32 x 16.27 mm (Plate 3 I-L); Beach collected, Umdloti, southern KwaZulu-Natal; NMSA-Mol. 4809/T4582.

Paratype 11: 27.33 x 15.93 mm; Beach collected, Port Shepstone, southern KwaZulu-Natal; NMSA-Mol. 4815/T4583.

Paratype 12: 28.53 x 16.85 mm; Beach collected, southern KwaZulu-Natal; R. Aiken Collection.

Paratype 13: 25.79 x 15.96 mm; Beach collected, southern KwaZulu-Natal; R. Aiken Collection.

Paratype 14: 27.46 x 17.56 mm (Figure x); Beach collected, southern KwaZulu-Natal; R. Aiken Collection.

Paratype 15: 27.74 x 16.95 mm; Beach collected, Pumula, southern KwaZulu-Natal; H. Smit Collection.

Paratype 16: 27.30 x 17.11 mm; Beach collected, southern KwaZulu-Natal; Veldsman Collection.

Paratype 17: 25.91 x 15.45 mm; Beach collected, southern KwaZulu-Natal; A. Groenewald Collection, donated by the Veldsmans.

Etymology. This species is named for Anton Groenewald, friend of the authors and provided numerous specimens used in this study.

Bistolida kosibayensis S.G. Veldsman & J.H. Veldsman, new species

(Plates 1 M-P, 2 A-H, Figure 3)

Description. Shell small (22-28 mm). Profile elongate-oval, small umbilicate spire. Dorsal profile slightly rounded to flat, the highest point is about one third from the posterior end. Labrum margin smooth to slightly irregular and strong marginal callus developed, curved on posterior side, largest portion of the center section slightly curved, curving in sharply at

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anterior side. Columella margin slightly oval, posterior columellar margin edge curving in a rounded manner high on profile, angling in sharply at the posterior extremity, anterior columellar margin edge curving in moderately, angling in sharply at the extremity. Base moderately flat, labrum flat, columella flat to slightly bulbous. Aperture, narrow and straight at center, posterior side narrow and curving slightly, anterior side straight and narrow. Labral teeth large and extending across labrum smoothing out towards the margin, 19 number of teeth. Columellar teeth large on posterior side and center extending to the columella margin, smoothing out at margin. Columella smooth from center to anterior side. Small teeth present on columella ridge and fossula.

The base color is blue-grey, consisting of five broad bands, posterior, center and anterior bands dark, with the other two being lighter colored. One large orange-brown blotch, split mid-dorsum just off center of the dorsum, labrum side, sometimes fingering out to the margin markings. Two orange-brown blotches on the labrum and two on the columellar margin, extending onto the dorsum. Both margins are covered with very sparse fine orange-brown spots, with a few spots on the dorsum (only visible in fresh specimens). Both extremities have orange-brown coloration on both sides. The base is light cream, light orange-brown staining visible on the middle columella teeth on fresh specimens.

Type locality. Scuba live (Figure 3) 20-24 m Kosi Bay, northern KwaZulu-Natal, South Africa.

Distribution. Specimens were recorded off Kosi Bay and Sodwana, KwaZulu-Natal, South Africa, and Mocambique Island, Mozambique. Specimens studied were scuba to depths of 24 m.

Type material.

Holotype: 27.69 x 15.23 mm (Plate 1 M-P, Figure 3); Scuba live 20-24 m Kosi Bay (off marker 17 north), southern KwaZulu-Natal; Coll. Natal Museum, Pietermaritzburg, South Africa: NMSA-Mol. S1748/T4587.

Paratype 1: 26.98 x 15.20 mm (Plate 2 A-B); Scuba live Sodwana Bay, southern KwaZulu-Natal; Veldsman Collection.

Paratype 2: 25.54 x 14.51 mm (Plate 2 C-D); Scuba live Mocambique Island, Mozambique; Veldsman Collection.

Paratype 3: 22.68 x 12.53 mm (Plate 2 E-H); Scuba 5-9 m between Bhanga Neck and Kosi Bay (reef off marker 13 north), northern KwaZulu-Natal; NMSA-Mol. S1464/T4586.

Paratype 4: 25.21 x 14.77 mm; Scuba 10-15m Sodwana Bay (Two Mile Reef), northern KwaZulu-Natal; NMSA-Mol. D1749/T4588.

Paratype 5: 25.06 x 13.44 mm; Scuba 23-24 m Kosi Bay (Main Reef), northern KwaZulu-Natal; NMSA-Mol. S1787/T4585.

Paratype 6: 23.44 x 13.36 mm; Scuba 18-20 m between Bhanga Neck and Kosi Bay (reef off point at marker 13), northern KwaZulu-Natal; NMSA-Mol. D9870/T4584.

Etymology. This species is named for the type locality, Kosi Bay, northern KwaZulu-Natal, South Africa.

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Figure 3. Live take picture of *Bistolida kosibayensis* n. sp. holotype (courtesy of Dai Herbert, photo taken with a 35 mm slide film, 1990). Photo also illustrated on page 436 of Lorenz (2018).

Bistolida jangamoensis Aiken & Seccombe, 2022 (Plates 1 Q-T, 2 M-P)

Shell characteristics. Shell small (23-32 mm). Profile oval, small umbilicate spire. Dorsal profile slightly rounded to flat, the highest point is about one third from the posterior end. Labrum margin smooth to slightly irregular and strong marginal callus developed, curved sharply on posterior side, largest portion of the center section curved, straightening towards anterior side. Columella margin oval, posterior columellar margin edge curving strongly in a rounded manner high on profile, angling in moderately at the posterior extremity, anterior columellar margin edge curving in moderately, straightening towards anterior extremity. Base slightly rounded, labrum rounded, columella bulbous. Aperture, broad at center, posterior side broad and curving slightly, anterior side slightly curving towards labrum side. Two large crenulations on posterior side of labrum. Labral teeth thick and large, and extending across labrum smoothing out towards the margin, 18-19 number of teeth. Older specimens the callus cover the crenulations and one tooth. Columellar teeth large on posterior side and center extending onto the columella, smoothing out at the center. Columella smooth from center to anterior side with small teeth present on columella ridge and fossula.

The base color is blue/green-grey, consisting of five broad bands, posterior, center and anterior bands dark, with the other two being lighter colored. One large orange-brown blotch, split mid-dorsum just off center of the dorsum, labrum side, sometimes fingering out to the margin markings. Two orange-brown blotches on the labrum and two on the columellar margin, extending onto the dorsum. Both margins are covered with very sparse fine orange-brown spots, with a few spots on the dorsum (only visible in fresh specimens). Both extremities have orange-brown coloration on both sides. The base is light cream, no staining visible on the teeth.

Type locality. Scuba Jangamo reef, Mozambique.

Distribution. Specimens were recorded off Jangamo and Inhambane, Mozambique, and Richards Bay, Port Dunford and Sodwana Bay, northern KwaZulu-Natal, South Africa. Specimens studied were beach collected, scuba to depths of 18 m, and *ex pisce*.

DISCUSSION

The three species from the southern KwaZulu-Natal include *B. uvongoensis, B. groenewaldi,* and *B. ronniewatti*, and occur sympatric across the range from Durban to Mzamba within the same habitat. The two other species *B. jangamoensis* and *B. kosibayensis* occur approximately 200 km north of Durban towards central Mozambique.

The more significant differences off *B. uvongoensis, B. groenewaldi, B. ronniewatti, B.*

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jangamoensis, and *B. kosibayensis* are summarized in Table 1 and 2, and the morphometric parameters is presented in Table 3.

The aperture shape and opening of each of the species discussed here is significantly different from each other as summarized in Table 1 and 2, and illustrated in Figure 4.

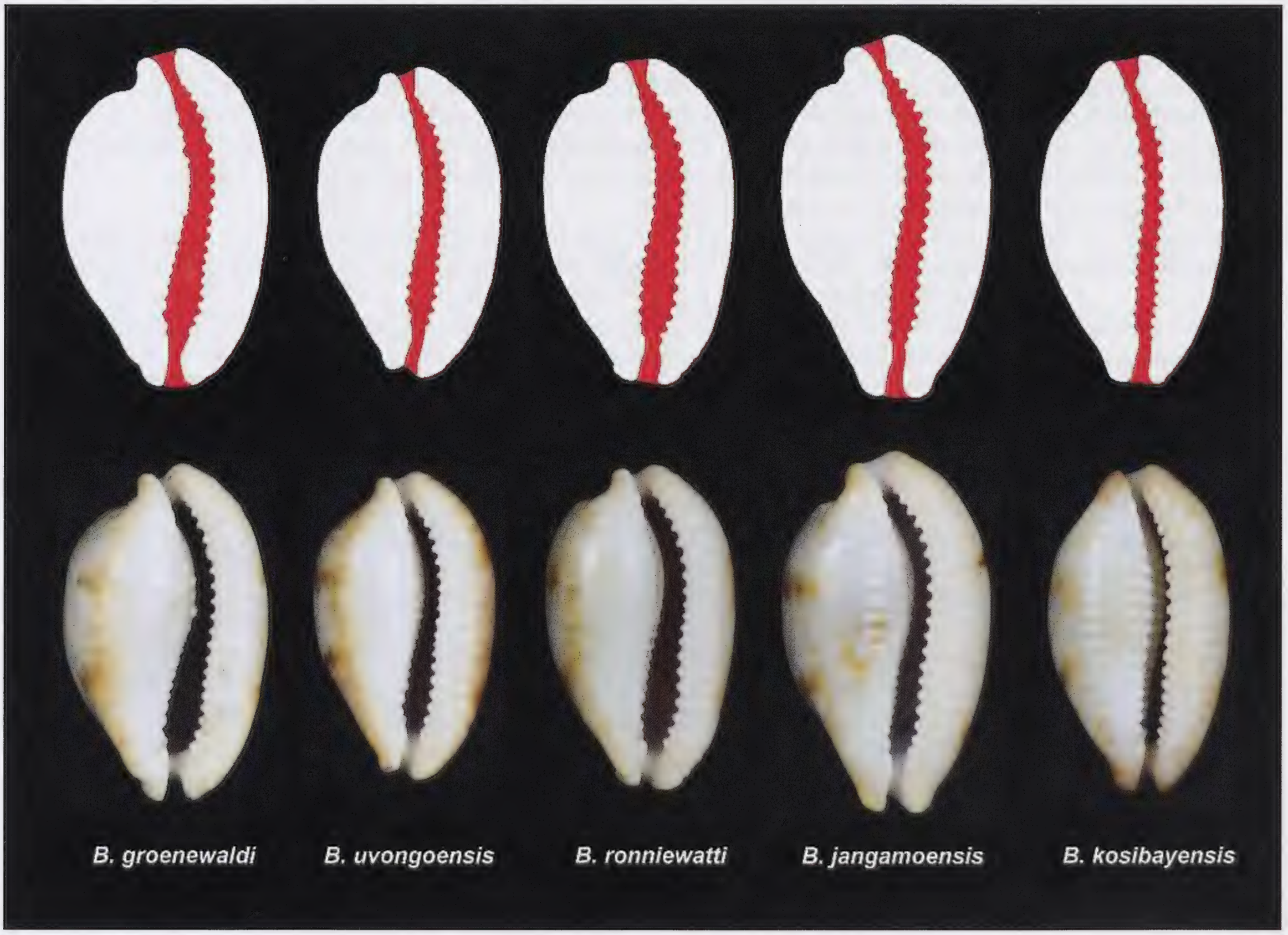

Figure 4. Aperture comparison between the five species studied.

	B. uvongoensis	***B. groenewaldi***	***B. ronniewatti***
Shell profile	Dorsal profile elongate-oval and slightly rounded to flat on top.	Dorsal profile oval and rounded, slightly flattish on top.	Dorsal profile elongate-cylindrical, slightly rounded to flat on top.
Labrum	Labrum curved on posterior side, small section straight at the center, curved from center to anterior side. Labrum base flat.	Labrum curved on posterior side, largest portion of the center section curved all the way to the anterior side. Labrum base flat to slightly rounded.	Labrum curved on posterior side, largest portion of the center section straight, curving in sharply at anterior side. Labrum base slightly rounded.

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Columella	Columella margin oval, posterior columellar margin edge angling in moderately, ending with a sharp curve at the posterior extremity, anterior columellar margin edge curving in moderately. Base slightly bulbous.	Columella margin oval, posterior columellar margin edge curving in a rounded manner high on profile, angling in sharply at the posterior extremity, anterior columellar margin edge almost stepped, curving in moderately at the end. Base bulbous.	Columella margin slightly oval, posterior columellar margin edge curving in a rounded manner high on profile, angling in sharply at the posterior extremity, anterior columellar margin edge curving in moderately. Base slightly bulbous.
Labrum teeth	Labral teeth moderately large and extending across labrum smoothing out towards the margin.	Labral teeth large and extending across labrum smoothing out towards the margin.	Labral teeth large and extending across labrum smoothing out towards the margin.
Columella teeth	Columellar teeth small, posterior side teeth faint extending across columella smoothing out towards margin, center teeth shortening, anterior side teeth only on aperture edge with columella being smooth.	Columellar teeth small, posterior side and center teeth faint extending just over the columella ridge, smoothing out towards the center of the columella, columella being smooth, anterior side teeth only on aperture edge with columella being smooth.	Columellar teeth small, posterior side and center teeth faint extending just over the columella ridge, columella being smooth, anterior side teeth only on aperture edge with columella being smooth.
Aperture (Figure 4)	Aperture, relatively straight at center, opening moderately narrow to narrow, posterior side curving slightly, opening moderately narrow to narrow, anterior side straight and moderately opening.	Aperture, slightly curved at center and narrow, curving strongly towards posterior side, staying narrow, center to anterior side opening very wide, curving strongly.	Aperture, slightly curved at center and opening wide, posterior side curving strongly, opening wide, anterior side straight and opening very wide.
Shell coloration	One large slightly perforated brown blotch present on the center of the dorsum. Two dark brown blotches on the labrum and two on the columellar margin. Both margins are covered with very fine brown spots, with the fine spots extending sparsely over the dorsum.	One large brown fragmented blotch, split mid-dorsum just off center of the dorsum, labrum side, fingering towards markings on margins. Two dark brown blotches on the labrum and two on the columellar margin, slightly extending onto the dorsum. Both margins are covered with very sparse fine brown spots, with a few to no spots on the dorsum.	One large brown blotch, with a split mid-dorsum on the center of the dorsum, sometimes fingering out or being split mid-dorsum. Two dark brown blotches on the labrum and two on the columellar margin, slightly extending onto the dorsum. Both margins are covered with very sparse fine brown spots, with a few to no spots on the dorsum.

Table 1. Summarized shell morphological differences between *Bistolida uvongoensis, B. groenewaldi* n. sp. and *B. ronniewatti.*

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	B. jangamoensis	***B. kosibayensis***
Shell profile	Dorsal profile oval and slightly rounded to flat on top.	Dorsal profile elongate-oval and slightly rounded to flat on top.
Labrum	Labrum curved sharply on posterior side, largest portion of the center section curved, straightening towards anterior side. Labrum base rounded.	Labrum curved on posterior side, largest portion of the center section slightly curved, curving in sharply at anterior side. Labrum base flat.
Columella	Columella margin oval, posterior columellar margin edge curving strongly in a rounded manner high on profile, angling in moderately at the posterior extremity, anterior columellar margin edge curving in moderately, straightening towards anterior extremity. Base bulbous.	Columella margin slightly oval, posterior columellar margin edge curving in a rounded manner high on profile, angling in sharply at the posterior extremity, anterior columellar margin edge curving in moderately, angling in sharply at the extremity, Base flat to slightly bulbous.
Labrum teeth	Labral teeth thick and large, and extending across labrum smoothing out towards the margin.	Labral teeth large and extending across labrum smoothing out towards the margin.
Columella teeth	Columellar teeth large on posterior side and center extending onto the columella, smoothing out at the center. Columella smooth from center to anterior side.	Columellar teeth large on posterior side and center extending to the columella margin, smoothing out at margin. Columella smooth from center to anterior side.
Aperture (Figure 4)	Aperture, broad at center, posterior side broad and curving slightly, anterior side slightly curving towards labrum side.	Aperture, narrow and straight at center, posterior side narrow and curving slightly, anterior side straight and narrow.
Shell coloration	One large orange-brown blotch, split mid-dorsum just off center of the dorsum, labrum side, sometimes fingering out to the margin markings. Two orange-brown blotches on the labrum and two on the columellar margin, extending onto the dorsum. Both margins are covered with very sparse fine orange-brown spots, with a few spots on the dorsum (only visible in fresh specimens). No coloration on base.	One large orange-brown blotch, split mid-dorsum just off center of the dorsum, labrum side, sometimes fingering out to the margin markings. Two orange-brown blotches on the labrum and two on the columellar margin, extending onto the dorsum. Both margins are covered with very sparse fine orange-brown spots, with a few spots on the dorsum (only visible in fresh specimens). Light orange-brown staining visible on the middle columella teeth on fresh specimens.

Table 2. Summarized shell morphological differences between *Bistolida jangamoensis* and *B. kosibayensis*.

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	Length (L) - mm	Width (W) - mm	Height (H) - mm	Labral teeth - amount
***Bistolida uvongoensis* (20 specimens studied)**				
Range	22.8 – 31.11	12.70 – 17.81	10.00 – 14.41	17 - 20
Mean	26.53	15.35	13.94	18
***Bistolida groenewaldi* n. sp. (18 specimens studied)**				
Range	23.77 – 28.53	13.89 – 17.56	10.25 – 14.01	18 - 19
Mean	25.96	15.48	12.24	19
***Bistolida ronniewatti* n. sp. (15 specimens studied)**				
Range	21.58 – 30.97	12.26 – 16.49	9.43 – 13.55	18 - 20
Mean	26.73	15.17	12.04	19
***Bistolida jangamoensis* (5 specimens studied)**				
Range	23.21 – 30.11	13.33 – 17.14	10.72 – 13.49	18 - 19
Mean	26.23	15.49	12.35	19
***Bistolida kosibayensis* n. sp. (7 specimens studied)**				
Range	22.68 – 27.69	12.53 – 15.23	10.09 – 11.94	19
Mean	25.23	14.15	11.13	19

Table 3. Morphometric parameters of *B. uvongoensis, B. groenewaldi, B. ronniewatti, B. jangamoensis,* and *B. kosibayensis*.

CONCLUSION

The three southern KwaZulu-Natal *Bistolida* species occur sympatric, occurring within the same geographic area and habitat, and are separated by the Tugela Bank (approximately 200 km) from the two *Bistolida* species that occur in the northern KwaZulu-Natal (north of Cape Vidal/St. Lucia). *Bistolida ronniewatti* is an elongate-cylindrical species, with *B. uvongoensis* being slightly more oval, still elongated, whereas *B. groenewaldi* is a very oval shaped species. *Bistolida jangamoensis* is very different from the other species discussed here, being oval and very robust, where *B. kosibayensis* is a very narrow elongated-oval species. The labrums of the five species discussed here, are significantly different as discussed above and illustrated in Figure 4. One can further clearly see the differences between

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the five species discussed here and *B. diauges* and *B. clavicola* as illustrated in Plate 2.

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The authors thank Sulize Veldsman for proof reading and support the during development of this paper. The authors further acknowledge Nelisiwe Mary Manukuza (Research Technician: Natural Science (Malacology)) for supplying photos of specimens in the Natal Museum and providing the type number. A special thanks to Anton Groenewald, Linda Swart, Henk Smit and Roy Aiken who provided several specimens used during the study. Dr. Vollrath Wiese from the Haus der Natur - Cismar (Natural History Museum) is thanked for supplying the holotype photos of *Bistolida uvongoensis*.

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NOVAPEX

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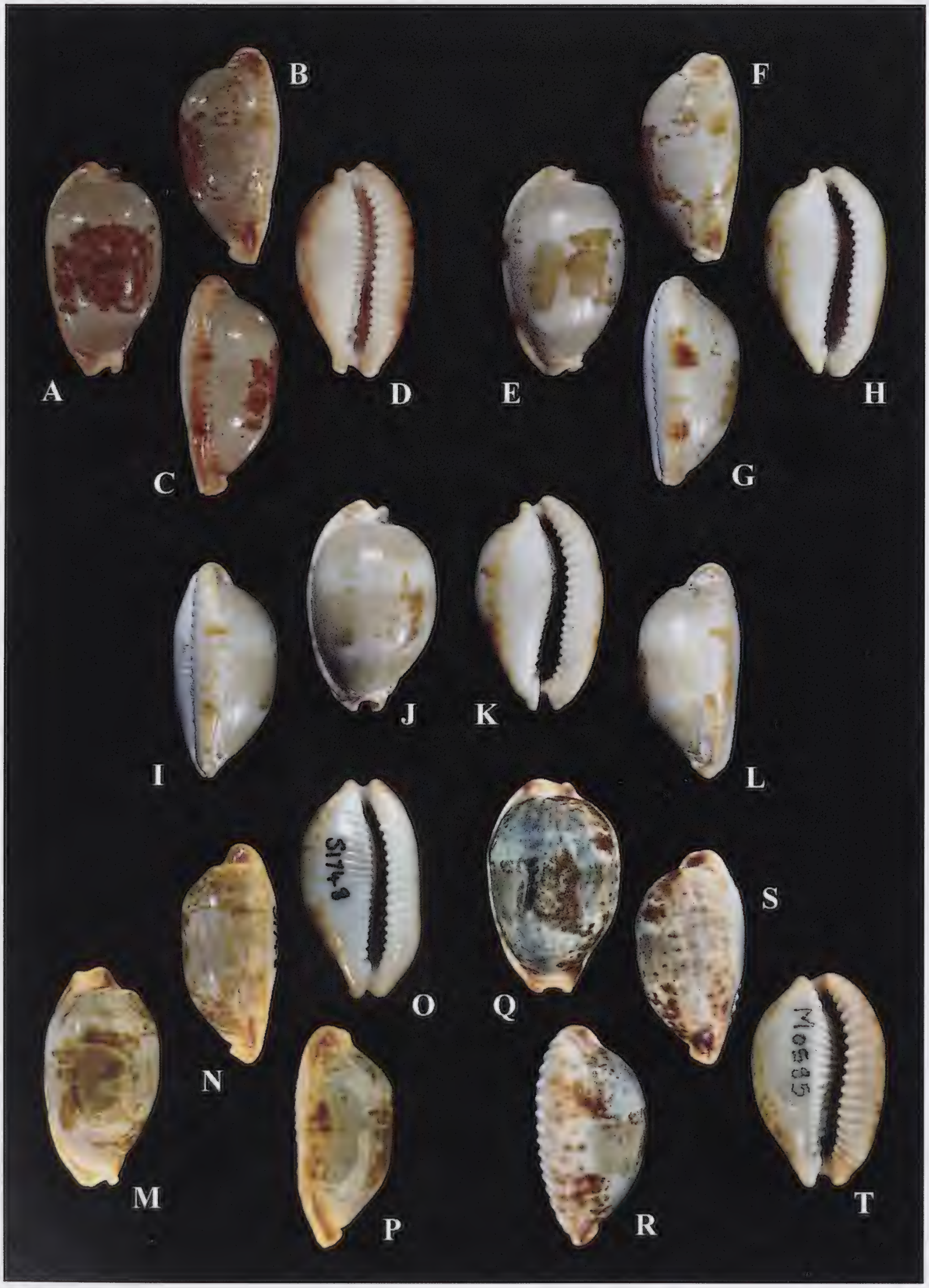

Plate 1. A-D=. *Bistolida uvongoensis* Holotype: 29.60 x 16.70 mm; Uvongo/Shelly Beach, southern KwaZulu-Natal; HNC 62712, photo courtesy of Dr. Vollrath Wiese, Haus der Natur - Cismar. **E-H=** *Bistolida ronniewatti* Holotype: 26.85 x 15.74 mm; beach collected, Mzamba, northern Eastern Cape / border of southern KwaZulu-Natal; NMSA-Mol. P2312/T4595. **I-L=** *Bistolida groenewaldi* Holotype: 27.72 x 15.73 mm; beach collected, Pumula, southern KwaZulu-Natal; NMSA-Mol. P2311/T4594. **M-P=** *Bistolida kosibayensis* Holotype: 27.69 x 15.23 mm; scuba live 20-24 m, Kosi Bay (off marker 17 north), northern KwaZulu-Natal; NMSA-Mol. S1748/T4587. **Q-T=** *Bistolida jangamoensis* Holotype: 23.21 x 14.71 mm; scuba, Jangamo reef, Mozambique, photo courtesy of Nelisiwe Mary Manukuza, NMSA.

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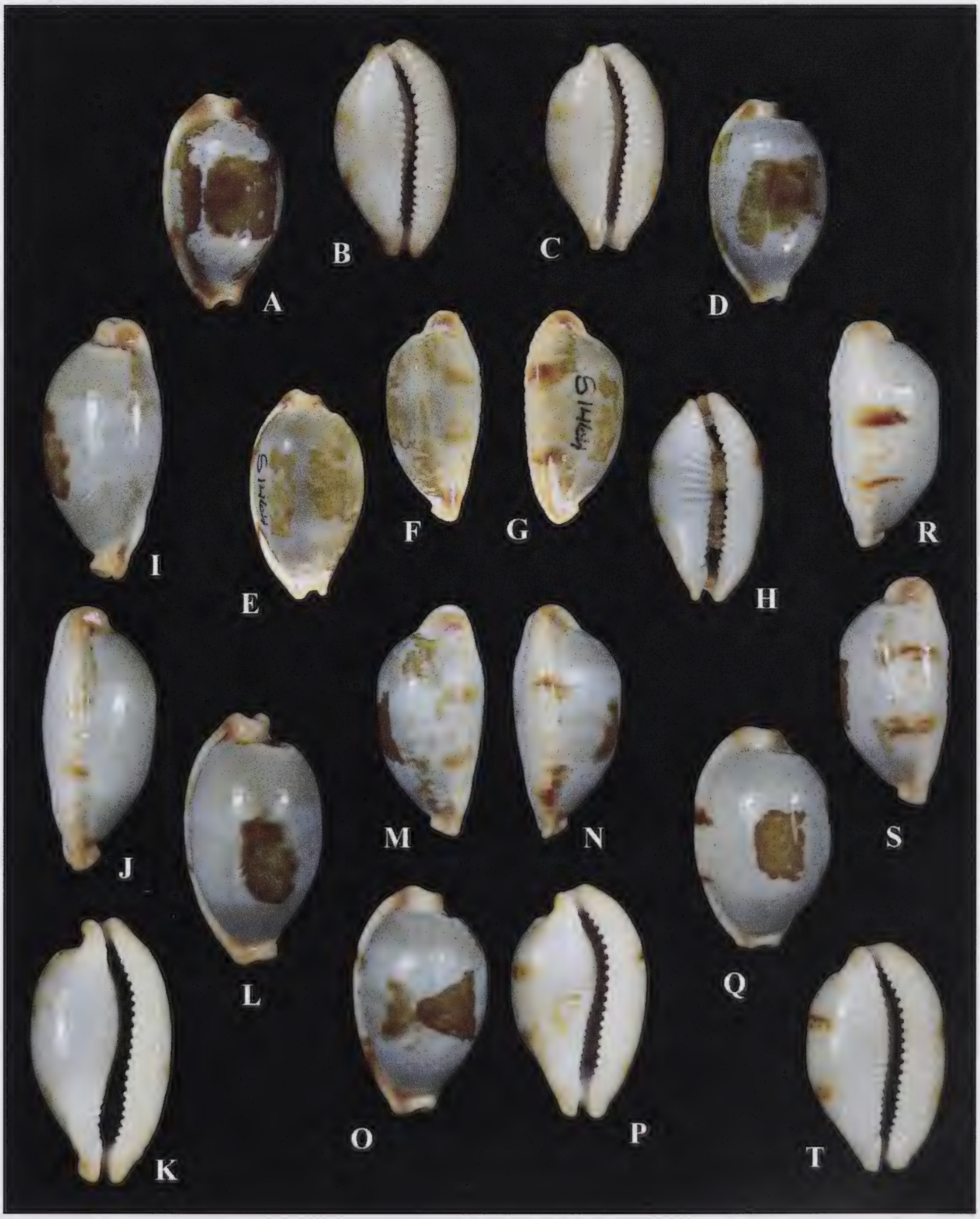

Plate 2. A-B= *Bistolida kosibayensis* Paratype 1: 26.98 x 15.20 mm; scuba live, Sodwana Bay, northern KwaZulu-Natal; Veldsman Collection. **C-D**= *Bistolida kosibayensis* Paratype 2: 25.54 x 14.51 mm; scuba live, Mocambique Island, Mozambique; Veldsman Collection. **E-H**= *Bistolida kosibayensis* Paratype 3: 22.68 x 12.53 mm; scuba 5-9 m, between Bhanga Neck and Kosi Bay (reef off marker 13 north), northern KwaZulu-Natal; NMSA-Mol. S1464/T4586; photo courtesy of Nelisiwe Mary Manukuza, NMSA. **I-L**= *Bistolida diauges*: 33.68 x 17.73 mm; scuba live 2-3 m, Fundo Island, Tanzania, Veldsman Collection. **M-P**= *Bistolida jangamoensis*: 29.62 x 17.14 mm; southern Mozambique, Veldsman Collection. **Q-T**= *Bistolida clavicola*: 29.17 x 17.79 mm; scuba live 1.5 m, Fungu Mkadya Reef, Dar es Salaam, Tanzania, Veldsman Collection.

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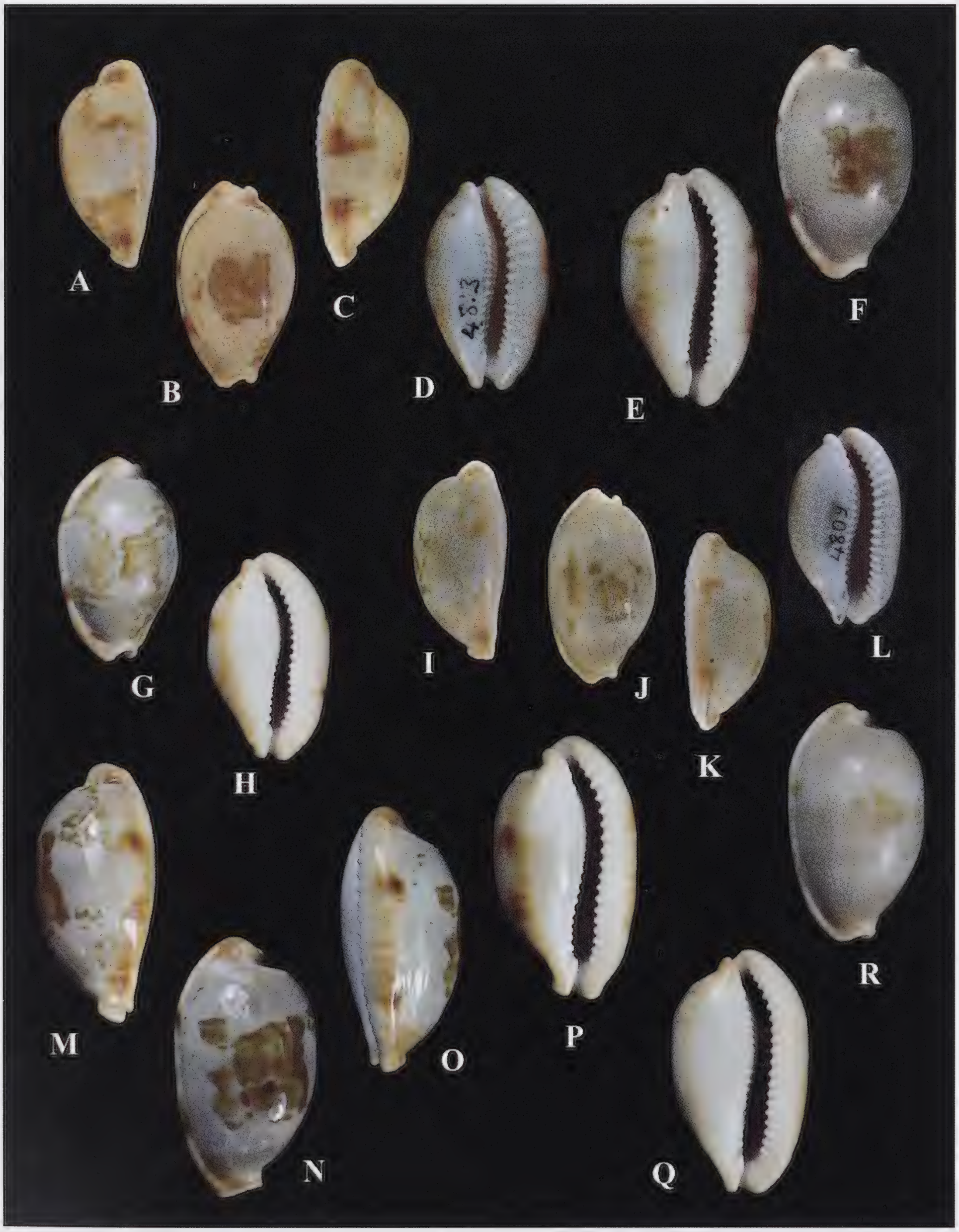

Plate 3. A-D= *Bistolida uvongoensis*: 25.73 x 14.50 mm; scuba, Melville, southern KwaZulu-Natal; NMSA-Mol. 4813; photo courtesy of Nelisiwe Mary Manukuza, NMSA. **E-F**= *Bistolida uvongoensis*: 27.62 x 16.24 mm; Beach collected, Pumula, southern KwaZulu-Natal, A. Groenewald collection. **G-H**= *Bistolida groenewaldi* Paratype 1: 24.35 x 14.64 mm; scuba 25m, Park Rynie, southern KwaZulu-Natal; Veldsman Collection. **I-L**= *Bistolida groenewaldi* Paratype 10: 28.32 x 16.27 mm; beach collected, Umdloti, southern KwaZulu-Natal; NMSA-Mol. 4809/T4582, photo courtesy of Nelisiwe Mary Manukuza, NMSA. **M-P**= *Bistolida ronniewatti* Paratype 1: 30.97 x 16.49 mm; live taken, Margate, southern KwaZulu-Natal; Veldsman Collection. **Q-R**= *Bistolida ronniewatti* Paratype 2: 28.49 x 16.13 mm; beach collected, Mzamba, northern Eastern Cape / border of southern KwaZulu-Natal; Veldsman Collection.

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Volume: 55 THE FESTIVUS ISSUE 1

Range Extension of a Predatory Sea Snail *Sulcerato recondita* (Melvill & Standen, 1903) in India (Gastropoda, Eratoidae)

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ABSTRACT A predatory sea snail *Sulcerato recondita* (Melvill & Standen, 1903) previously reported from South Africa and Gulf of Oman, is reported for the first time from Gulf of Kachchh in India. The detailed description along with an illustration, and information on distribution of the species is provided herein. The nearest distribution record for *S. recondita* is from Fujairah coast in United Arab Emirates, which is ~ 1500 km from the present location of its reporting in India.

KEY WORDS Caenogastropoda, predatory sea snails, distribution, new record, Gulf of Kachchh, India

INTRODUCTION

Eratoidae, a family of small predatory sea snails is assigned to the superfamily Velutinoidea (Ponder & Lindberg, 2020), with 10 valid genera and having around 155 species, that are widely distributed across the globe (MolluscaBase eds. 2022). The genus *Sulcerato*, with six valid nominal species is reported to have been mostly restricted to Indian and Pacific Oceans. *Sulcerato recondita* (Figure 1) is a distinct species, restricted to Western Indian Ocean, Western Arabian sea and Red Sea (Cate, 1977; Liltved, 2000; Fehse, 2013). However, no species belonging to the genus *Sulcerato* has ever been reported from Indian waters (Ray, 1948; Subba Rao, 2003; Dey, 2016).

As part of the Annual Program of Research, is assigned to the Zoological Survey India (ZSI) by Ministry of Environment, Forest and Climate Change, Government of India. The survey was conducted along the Shore of Pirotan Island in Marine National Park, Gulf of Kachchh, Gujarat during 2016–2017. Seven dead shells were beach collected and identified as *S. recondita* based on the original descriptions by Bosch *et al.* (1995), and Fehse (2013). The identified shells were deposited in the National Zoological Collection of Zoological Survey of India (NZSI), Kolkata (India) for future reference.

Family Eratoidae Gill, 1871

***Sulcerato recondita* (Melvill & Standen, 1903),** was described from "Gulf of Oman, lat. 24°58' N., long. 56°54' E., 156 fathoms" (Melvill & Standen, 1903: 302), and reported from Gulf of Oman, Israel (Red Sea), KwaZulu-Natal (RSA), Maldives, Mozambique, Reunion, Tanzania (Cate, 1977; Liltved, 2000; Fehse, 2013).

New Record. Gulf of Kachchh, Pirotan Island, Jamnagar district, Gujarat (22° 35′ 54.79″ N, 69° 57′ 47.88″ E), (NZSI M.35407/10) (*leg.* A. Mukhopadhyay, 26 October 2016). Seven dead shells (See Figure 1).

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Keys to the species of Eratoidae found in India:

Shell small, (height 3-4.5 mm) and granules over whole shell with forming short axial riblets, and presence of dorsal longitudinal groove ..... *Eratoena sulcifera* (Gray in Sowerby I, 1832)

Shell small, (height 2-5 mm) relatively minutely pustulated or wrinkled throughout; spire elevated and dorsal sulcus mostly absent, columellar dentition coarser posteriorly obscured ..... *Alaerato angistoma* (Sowerby I, 1832)

Shell small, (height 4.8-5.2 mm) without granulation, apical whorl obtuse, spire nipple like, lower half of the columella lip either weakly denticulate ..... *Sulcerato recondita* (Melvill & Standen, 1903)

Description. Shell small (Shell height 4.8-5.2 mm, Shell width 2.8-3.2 mm), shiny, solidly formed; globose-ovate; body whorl smooth and spotless, apical whorl obtuse, spire nipple like; whorls 5½ in number; body whorl large covers almost entire length of the shell; aperture almost straight and slightly shorter than the length of the shell, narrow and slightly curved; Outer lip slightly extravagant with numerous minute denticulate, lower half of the columella lip either weakly denticulate, or becoming obsolute.

Remarks. Fehse (2013), indicated that, the color varies from white to light green and sometimes light brown and the inflation of the shell and the height of the spire vary.

DISCUSSION

Ray (1948) revised the Cypraeacea specimens housed in the NZSI and reported only *Proterato sulcifera* race *smithi* Schilder, 1933 from Bombay coast. Recently, Dey (2016) reported *Alaerato angistoma* (Sowerby I, 1832) from Maharashtra and *Eratoena sulcifera* (Gray in Sowerby I, 1832) of Eratoidea (=Eratoinae) from Andaman and Nicobar Islands, India. Nevertheless, the study of Velutinoidea (= Cypraeacea) from India is poor due to inadequate collections from throughout the coastal areas. The type locality of *S. recondita* is Gulf of Oman, and reported from Indian Ocean. Interestingly, it is noticed that the faunal composition of Marine National Park, Gujarat closely resembles that of Persian Gulf, Gulf of Arabian and Red Sea (Dey, 2016; Mukhopadhyay *et al.* 2019). Thus, the presence of *S. recondita* in Gulf of Kachchh Marine National Park is not surprising, and this record extends the known distribution range of the species.

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Figure 1. *Sulcerato recondita,* approximately 4.5 mm in length. First report of this species from India. Beach collection on Pirotan Island in Marine National Park, Gulf of Kachchh, Gujarat, India, as part of Zoological Survey of India.

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Volume: 55 THE FESTIVUS ISSUE 1

Biology of the Wavy Top Turban *Megastraea undosa* (Wood, 1828) from Southern California, and the Baja California Peninsula (Turbinidae)

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ABSTRACT *Megastraea undosa* (Wood, 1828) and *M. turbanica* (Dall, 1910) constitute a notable fishery in Baja California, México and a much smaller fishery in southern California, USA. The *in situ* diet of *M. undosa* includes over 30 genera of marine algae. New data from southern California are presented and compared to research from México. Information regarding the habitat of early age classes, change in shell shape with age, growth rates, longevity, and muscle weight vs. basal diameter are presented. California State Fish and Wildlife data for commercial landings of *Megastrae*a for the past 23 years indicate 75 % of the catch has been taken off San Diego, California. Among *M. undosa* with basal diameters of 90 mm or greater, approximately 15.5 % of the gross weight is edible muscle.

KEY WORDS *Megastraea,* diet, longevity, depth, commercial catch

INTRODUCTION

Within the gastropod family Turbinidae, McLean, 1970 assigned *Astraea undosa* (Wood, 1828) and *A. turbanica* Dall, 1910 to a new subgenus *Megastraea.* That decision was based on shell size, pattern of radial ridges, the heavy fibrous periostracum, and the uniquely ribbed-calcareous operculum. In Marine Shells of Southern California, 2nd edition McLean (1978) continued to use *Astraea* as the genus and *Megastraea* as the subgenus for *A. undosa*; *Astraea turbanica* appears to have been outside the scope of that publication. Hickman & McLean (1990) revised the superfamily Trochacea (now Trochoidae) and *Megastraea* as a subgenus of *Astraea* was retained. It is not clear when or by whom *Megastraea* was elevated to a full genus, but *Megastraea* was used by California Fish and Wildlife (Taniguchi & Rogers-Bennett, 2001). Williams *et al*. (2008) reviewed the molecular genetics of the Turbinidae, Trochidae, and Trochoidea, and those results indicate that both *Megastraea* and *Pomaulax* from the Pacific coast of North American are distinct from *Astraea/Lithopoma* of the western Atlantic.

The goals of this paper are to: (1) examine both the depth and habitat of *M. undosa,* (2) review extensive life history information published primarily in México, (3) present new information from California regarding age and growth, (4) provide initial data on the relationship between shell size, age and muscle weight, and (5) present a brief review of the commercial fishery for *Megastraea* in both southern California and the Baja peninsula of México. Other observations and data are presented.

Although *M. undosa* and *M. turbanica* are similar in general appearance, these two species are easily identified by their profile and opercula. Both have a prominent peripheral undulating radial cord with regularly spaced nodules. *Megastraea undosa* has one such cord with the suture immediately below, thus the shell is conical and typically only the radial cord is projecting (Figures 1a-b). Some *M. undosa* may have an enlarged nodule at the base of each

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axial ribs (Figures 4 & 5) but do not fuse to form a solid second radial cord. *Megastraea turbanica* has two undulating radial cords with an imperforation between, both of which are equally prominent on the early whorls. On later whorls, the suture is often on the shoulder of the lower cord making it appear diminutive compared to the upper cord. The prominent constriction between the two cords gives the profile a rough and slightly bulbus appearance The axial ribs of *M. turbanica* are solid, less numerous, and often twice as wide as those of *M. undosa* (Figures 8a & b).

The calcareous operculum of both species has three strong ridges on the outer surface. The operculum of *M. undosa* is elongated, the length to width ratio (L:W) average of 1.25; the ridges of the operculum are somewhat parallel until they meet near the apex; all three ridges have a rough texture (Figure 1c). The operculum of *M. turbanica* is more oval with an average L:W ratio of 1.45; the upper opercular ridge is rough, while the two lower ridges are typically smooth, and they fold as they approach the apex (Figure 8c). Both species of *Megastraea* are harvested commercially for their meat, and the authors have observed the polished shells sold in shops from Europe to Australia.

The most northern record for *M. undosa*, is Avila Beach, just north of Shell Beach, San Luis Obispo Co. California, Alf (2019). The current expected range remains from Point Conception (34º27'04N-120º28'16W), Santa Barbara Co., California, south to the area of Punta Pequeña which forms the headlands of Bahía Scorpion (26º13'52 N-112º.29'29 W) and the community of San Juanico, Baja California Sur, México (BCS). San Juanico is in the transitional zone between the temperate California Marine Province and the tropical Panamic Marine Province.

Martone & Micheli (2012) cited Morris *et al.* (1980) indicating that *M. undosa* occurs further south to Bahía Magdalena in BCS, that location is incorrect. Abbott & Haderlie (1980) *in* Morris *et al.* (1980), stated the southern record for this species [at that time] was Isla Asuncion, which is approximately 350 Km NW of Bahia Magdalena. The type locality of *M. turbanica* is from the area of Bahía Magdalena, BCS (Dall, 1910) and may have been the source of confusion. The type specimen of *M. undosa* was illustrated by Wood (1828), with the type locality listed only as California.

Because the apex of large *Megastraea* shells may be eroded, the height of those shells can only be estimated. The most reliable measurement of size is the basal diameter (BD) and is the standard regulatory measurement in México. The term 'mature' is applied to large shells in age class 10 or greater. The distinction is made because sexual maturity may occur as early as age class 5, at which time the basal diameter may be only half that of a mature shell. Initially, *M. turbanica* was to be included in this paper, but sufficient numbers of various age classes for a meaningful statistical comparison with *M. undosa* have not been found, but will be the subject of a future paper.

Abbreviations

AE = Assimilation Efficiency
Avg = Average
BC = Baja California, México
BCS = Baja California Sur, México
BD = Basal Diameter of shell
CA = California
H/W = Height to Width ratio
OP = Operculum
STD = Standard Deviation

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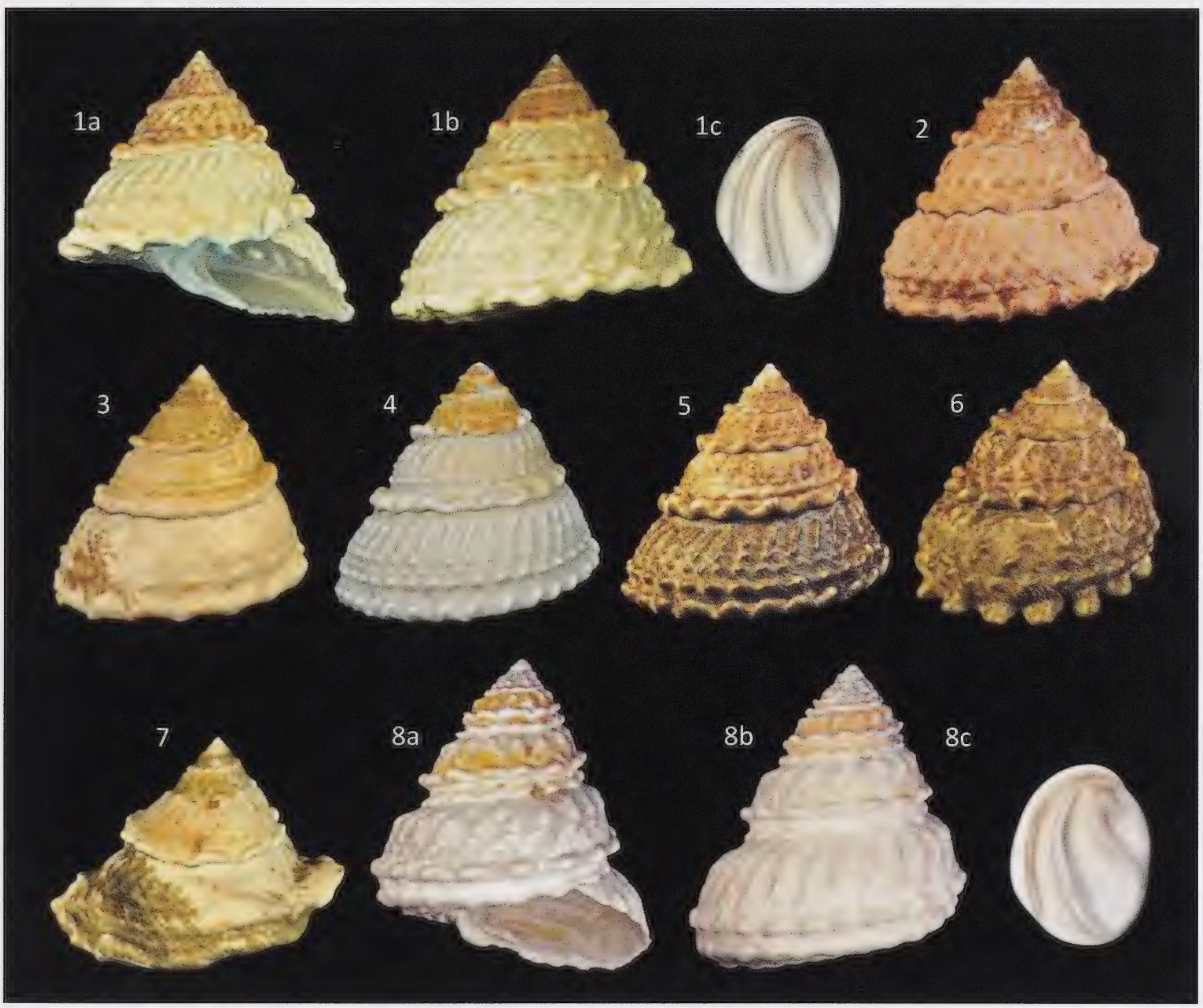

Figures 1-8: 1a-1b. *M. undosa*, basal diameter 110 mm, height 112 mm, typical phenotype with strong undulating radial cord. **1c.** External operculum, length 45.5 mm. *M. undosa* range of variation (**2-5**): **2.** Pink, with strong axial ribs extending to radial cord. **3.** Yellow-cream, axial nodes and ribs absent, radial cords with reduced undulation **4.** Typical form, Isla Guadalupe, BC, México. **5.** Typical form with periostricum and some free nodes in axial ribs. **6 & 7.** Unique aberations. **6.** Nodules of radial cord of final whorl enlarged and oriented down vs horizontal, with heavy periostricum. **7.** Shell with projection on opposite sides, radial cord present but simple. **8a-b**. *M. turbanica,* basal diameter 137 mm, height 153 mm. **8c**. External operculum, length 59.6 mm.

METHODS

Megastraea were collected while SCUBA diving in Mission Bay, Point Loma and La Jolla, San Diego, CA. The series of *Megastraea* measured from Isla Guadalupe, BC, were harvested commercially and purchased at the island approximately 30 years ago.

San Diego shells were cleaned with a wire brush and then a scraper to remove surface debris such as algae, barnacles, tunicates, *Crepidula,* tube worms and then placed in plastic bags and frozen. After two days shells were thawed, and excess liquid removed by loosening the foot, so that trapped water and mucus could drain. An identification number, in pencil, was assigned to the shell and corresponding operculum and

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information recorded as follows (1) basal diameter (BD), (2) shell height, (3) gross weight, (4) weight of the cleaned foot, minus the operculum, (5) operculum length and (6) number of growth increments on the operculum, and distance between each increment. When comparing *M. undosa* growth between Mission Bay and La Jolla, a one tailed *t*-test, was used to evaluate both opercular length and basal diameter.

Two methods were attempted to estimate age based on research in México. (1) External annual growth lines on the shells required carefully cleaned and the shell bleached in order to reveal growth patterns on the shell. That method was both time consuming, and growth lines were often lacking. (2) An alternative method utilized a dissecting scope to count and measure distance between growth rings on the operculum proved to be reliable and reproducible. The rings of the operculum was the method used in this study. Data from both locations was maintained separately.

As part of a different study, underwater transects were conducted off Isla Coronado del Norte, BC, México. The effort was a pilot study focused on evaluating methods, statistics, and resources for a larger effort to evaluate gastropod diversity and richness in similar habitats and depths on a north-south gradient. The target areas had similar rock habitat and the depth averaged 14-16 m. Each transect was 20 m^2 and scored by two divers. Ten transects were conducted at each site and no rocks were turned, nor were animals collected.

RESULTS

Annual opercular growth rings provide an estimate of age, which was correlated with opercular length for each age class (Table 1). The operculum length of similar age classes from Mission Bay and La Jolla varied slightly, but insignificantly (*t*-test $P < 0.05$). At age class 12, the average OP length for these two locations varied by only 0.5 mm. The sample size from Mission Bay was 140 specimens, and 62 specimens from La Jolla. The La Jolla sample was less, because six age classes were not present (Table 2).

Age class data for each specimen was then correlated with its BD to generate a chart allowing an estimate of age based upon a single BD measurement (Table 2). Except for age class 11, there was no significant difference in BD between *M. undosa* from Mission Bay and La Jolla. Age class 11 from Mission Bay was significantly smaller ($P > 0.001$) than specimens of the same age from La Jolla.

Data in Table 3 indicates that *M. undosa* from Isla Guadalupe, BC does not represent a dwarf population as suggested by Alf (2019). The general shape of the shells is consistent with those from San Diego. Graph 1 documents the change in shell shape as *M. undosa* continues to grow. Graph 2 presents the correlation between edible muscle (grams) associated with varying basal diameters of *M. undosa*.

DISCUSSION

Growth – Size – Age: The best measure of shell size is the basal diameter, as notable erosion of the apex may occur among large specimens. In México the BD, not the height of the shell, is used to determine the minimum legal size for harvest. Two methods have been used to determine age: growth lines on the operculum and growth lines on the shell (Cupul-Magana & Torres-Moye, 1996, Gluyas-Millán *et al.*, 2000, Marton & Micheli, 2012). In San Diego, the level of certainty using annual growth marks on the external shell surface proved to be unsatisfactory. Determination of

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age based on opercular (OP) growth lines was productive and reproducible, but some subjectivity is still involved. By counting opercular rings and measuring the distances between intervals, growth history information for prior years can be obtained. As a result, age class 12 could yield a dozen OP growth lines, and one basal diameter measurement.

Typically, not all individuals in the same age class grow at a similar rate. Snails that grow faster or slower, may have a BD that overlaps early or later age classes. Based on annual opercular growth lines for the San Diego area, it is estimated that 7 % of the sample may be improperly assigned (+/– 1 year) when using BD data (Table 2) as a measure of age. The error is most likely to occur in age classes with greater standard deviation in BD. On the positive side, using localized BD data that has been correlated with age does not require additional animals to be sacrificed when estimating the age of an individual or the age class structure of the population. As a result, the measurements of BD can be recorded easily while underwater or on land, and the age estimated (Table 2). The data in Table 2 is relevant to the San Diego area where 75 % of *Megastraea* have been commercially collected in California.

Research on the Baja California Peninsula has demonstrated the need for localized data regarding age class charts, due to variation in growth rates in different fishery management zones. Most studies have dealt with the primary fishing grounds in BC and BCS, and provide comparative data. The following authors estimated the average BD for age class 12 at their study sites: Martone & Micheli (2012) Bahía Tortugas 109 mm and Punta Abreojos 121 mm; Cupul-Magana & Torres-Moye (1996) Bahía de Todos Santos 80 mm; Gluyas-Millán *et al.* (2000) five locations 122.4-128.9 mm (not all locations contained age class 12); Gluyas-Millán *et al.* (1999) Bahía Tortugas 105 mm. None of these authors reported *M. undosa* older than age class 12. The variability reported above may be influenced by water temperature, habitat quality, availability of food, population density, and other biotic and abiotic factors that influence the habitat quality, which in turn, may promote or retard growth. In addition, excessive commercial harvest has also been shown to impact both size and age class structure of a population Rodríguez-Valencia *et al.* (2002).

With one exception, no notable difference in BD was found between the shallow waters of outer Mission Bay and the deeper waters off La Jolla (Table 2). The exception being age class 11; those individuals from Mission Bay were significantly smaller (5.5 mm) than those from La Jolla ($P > 0.001$) (n=26). The reason for the variance in age class 11 is unknown. The length of the OP for age class 11 at both locations were similar and did not reflect the difference in BD. At age class 12, the average BD was not statistically different between the two locations (Table 2).

There was a clear preponderance of larger snails, age classes 11-14 found off-shore, while early age class shells were rarely observed. As such, when evaluating BD, the sample size for ages 1-6, from La Jolla were not sufficient for statistical analysis with Mission Bay. The reverse was true for Mission Bay as age class 12 was uncommon, while all early age classes were commonly found (Table 2).

Isla Guadalupe is an isolated location approximately 255 km off the west coast of BC, México. The authors had the opportunity to examine and measure 29 commercially collected shells from the island. The average BD, height, and shell shape (height/BD ratio) fell within the range of shells from San Diego

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(Table 3). All of the Guadalupe shells were over the legal limit of 90 mm BD and were purchased on the island, in the past. Alf (2019) incorrectly reported the Isla Guadalupe population to being dwarf, not exceeding 80 mm in BD.

The arrangement of the axial pattern and radial cord of *M. undosa* from Isla Guadalupe is not unique, as similar patterns are found in Mission Bay, La Jolla, and Point Loma. Chance (1958) indicated the shells from Isla Guadalupe were "apparently more variable than on the mainland". Of the 29 shells examined by the authors the range of variability appeared similar to that observed in southern California and Baja California. Isla Guadalupe is isolated, but isolation alone is not a criterion for a new species or subspecies. Haupt *et al.* (2013) suggest that *M. undosa* recolonized the northern portion of its current range after the last period of glaciation. The extent of gene flow between the mainland and the island is not known.

Shell Variation. The shells of *M. undosa* are variable both in shape and color. The small nodes usually coalesce to form a series of diagonal, narrow shallow axial ribs (Figures 1, 2, 4) with a slight enlarged nodule ending just above the undulating radial cord, or may consist of a series of fused and isolated nodes that form axial ribs (Figure 5). The radial cord above the suture is undulated with raised nodules. When the axial ribs are poorly developed or nearly absent (Figure 3) the radial cord may lack notable undulations and minimal nodules.

The shell color of first 3-6 whorls may be pink, cream, white, yellow (Figures 1-4), or orange. By age class 9 (BD 95 mm) the newly deposited shell is usually white. With age, pigments tend to fade but may remain present on the upper most whorls. The coloration is not apparent until the fibrous brown periostracum (Figures 5 & 6) is removed. The number of cords on the base of the shell varies from 2-5 with 98% having 3-4 cords (n = 50).

Two of 140 shells collected in Mission Bay displayed abnormal growth. One shell (Figure 6) had extremely thick periostracum and the nodules on the radial cord of the last whorl were large and oriented down rather than horizontally. As a result, the shell rests on the nodules rather than the ventral surface. A second shell (Figure 7) exhibited large, broadly flattened lobes projecting horizontally from opposite sides of the last whorl.

While taking BD and height measurements of *Megastraea undosa*, it was observed that shell shape gradually changed with growth/age. Initially the BD of the shell is greater than the height (Graph 1). As the shell grows, they may approach an equilateral triangle. Approximately 23% of the shells may become taller than wide.

Depth - Size - Habitat. Off-shore, snails are found on rocky reef that support dozens of algal species, and often large species of kelp. Alf (2019) suggested that *Megastraea undosa* occurs on gravel bottoms near rocks at depths to 10 m and is then replaced by *M. turbanica* where the two species are sympatric. That is not correct. Gravel bottoms are exceedingly uncommon in southern California and Baja California. Further, gravel would be an unsuitable substrate for the attachment of kelp and other macro algae in the open ocean. Off-shore, snails are found on rocky reef, or in Mission Bay on large boulders that line the jetty. Small to mid-sized snails may be observed among eel grass beds where the channel opens into the bay and beyond. *Megastraea undosa* has a diverse diet, and is not dependent on kelp nor limited to a 10 m depth. The authors commonly observe *M. undosa* to 25 m, which is the deepest they typically dive.

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Taniguchi & Rogers-Bennett (2001) of California Fish & Wild Life, reported *M. undosa* at a depth of 82 m (250 ft.). They also discussed a shell with a BD of 150 mm taken at Farnsworth Bank, west of Santa Catalina Island, at a depth of 36.5 m (120 ft). Few *M. undosa* of similar size were located in both the collections of the San Diego Natural History Museum and the Natural History Museum of Los Angeles, but could not be aged, as no opercula were associated with the specimens. A shell in the present study, collected from La Jolla had a BD of 137 mm and an OP length of 56.3 mm, the snail was starting its 14th year, it is likely that a BD of 150 mm is age class 15.

Gluyas-Millán *et al.* (2000) and Cupul-Magana & Torres-Moye (1996) refer to the early stages as being either rare or cryptic as they were infrequently observed at their study cites. In the current study the authors failed to find the early age classes at off-shore La Jolla (Table 2). In Mission Bay age classes 1-5 were common in the outer bay at a depth of 0.5 to 1.5 meters below mean low tide. The juvenile snails are found in protected rocky habitat covered with various species of coralline algae. On the east side of Mariners Basin, early age classes were also common in shallow water associated with beds of eel grass. The early age classes are neither rare, hidden, or cryptic; they were found in a different habitat than snails of the size taken commercially. Schwalm (1973) and Alfaro & Carpenter (1999) also reported finding early age classes in shallow water and noted the general absence of early age classes in deeper water.

Despite dozens of dives over a period of three years off La Jolla the authors failed to find adequate numbers of age class 6 and less for statistical analysis with material from Mission Bay. Those early age classes would have a BD of 25 to 70 mm, and be too large to have been overlooked, especially since they were readily found in the shallows of Mission Bay.

The largest shell measured from Mission Bay had a BD of 121 mm and was age class 12, which is uncommon in the bay, where the vast majority of the shells with a BD greater than 90 mm were age classes 9-11. Off-shore at La Jolla, age classes 9-13 where common resulting in a disproportional number of larger shells (Table 2 & 3) and a larger average BD than the Mission Bay sample for shells equal to or greater than 90 mm BD.

Diet Review. In the *Seaweeds of the Pacific Coast* Mondragon & Mondragon (2003) apply the common name kelp to numerous species of large marine brown algae that may grow greater than 2 m in length. Although many algal species would be considered to be kelp based on that definition, when discussing kelp beds in southern California and Baja California, *Macrocystis pyrifera* (Linnaeus) C. Agardh, 1820 and *Egregia menziesii* (Turner) Areschou, 1876 are typically the dominant components. Kelp beds are not a monoculture, as dozens of additional macro species of red, brown, and green algae are present on the rocky reefs.

Laboratory studies have used various methods to determine feeding hierarchy, with the measure focused on selection and consumption. Limitations of such studies include the number of algal species tested, seasonality and geographical preference. Leighton (1966) conducted early studies regarding the diet of *M. undosa* and other kelp bed mollusks.

Dietary studies have become more sophisticated, both in methods and analysis. Coarse estimates of food value are frequently based on C:N and % Assimilation Efficiency (% AE) which includes C:N. Proximal analysis of algae is far more revealing and includes carbohydrates,

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lipids, amino acids, protein and, based on the characteristics of the herbivore, estimates of caloric value may be possible (Castro-Gonzalez *et al*. 1994). Schwalm (1973) combined assimilation methods with physiological and respiration studies to develop a model reflecting energy use/allocation by *M. undosa*.

The use of stable isotope analysis can enhance the knowledge of current and past diets and the flow of energy through portions of an ecosystem. Piñón-Gimate *et al*. (2016) compared the diet of *Megastraea undosa* with that of the commonly sympatric giant keyhole limpet *Megathura crenulata* (G.B. Sowerby I, 1825) via stable isotope analysis. As expected, *M. undosa* is primarily an herbivore while *M. crenulata* thought to be an herbivore is in fact, an omnivore.

Cox & Murray (2006) combined current analytical methods with two-choice laboratory experiments to evaluate food value and diet preference. They tested 12 species of algae and found the % AE was lowest among the kelp and highest among other algae such as *Pterocladiella capillacea* (S.G. Gmelin, 1768) Santelices & Hommersand, 1997 and *Halidrys dioica* Gardner, 1913. They pointed out that the selection of kelp such as *M. pyrifera* with a lower % AE by *M. undosa* seemed counter intuitive and discussed possible evolutionary factors that may have contributed to food selection such as chemical defenses or lack thereof.

Aguilar-Rosas *et al.* (1990) studied the diet of *M. undosa* based on analysis of gut content from snails collected at Punta Banda, just south of Ensenada, BC. They identified 17 genera of algae that were consumed, of which 10 were identified to species. In order of consumption from highest to lowest was *Sphacelaria rigidula* Kützing, 1843, *Gelidium pusillum* Collins, 1903, *Jania* sp., and *Corallina* sp. Some seasonality was shown in the consumption of *Cladophora columbiana* Collins, 1903, *Lithothrix aspergillum* (Gray, 1867), and *Polysiphonia eastwoodiae* Setchell & Gardner, 1930. Pronounced seasonality was observed in the remaining species (still in order of utilization) *Pterosiphonia dendroidea* (Montagne) Falkenberg, 1901, *Laurencia* sp., *Herposiphonia tenella* (C. Agardh) Ambron, 1880, *Ceramium* sp., *Lithothamnion californicum* Foslie, 1900, *Centroceras clavulatum* (C. Agardh) Montagne, 1846, *Hincksia mitchelliae* (Harvey) P.C. Silva, 1987, *Callithamnion* sp., *Ulva* sp., and *Enteromorpha* sp.

Recently Mazariegos-Villarreal *et al.* (2017) published the results of *M. undosa* gut analysis at three locations in BCS; the samples were collected periodically over the course of a year. The snails consume 30 genera of algae, one species of vascular plant *Phyllospadix sp*., and various taxa of invertebrates. The diet varied seasonally and by location. Various species of red and brown algae with *Macrocystis*, *Ecklonia,* and *Corallina* was consumed at all locations. Others algal species were eaten less frequently and/or seasonally. They speculated that invertebrates were incidentally consumed as a result of living epiphytically on algae, but noted that consumption of ascidian tunicates may have been purposeful.

Based on gut analysis of field collected animals, Aguilar-Rosas *et al.* (1990) and Mazariegos-Villarreal *et al.* (2017) identified 31 non-overlapping genera of algae consumed by *M. undosa.* There is little doubt that similar studies at other locations, perhaps further north, will identify even more genera in the diet of this species. The broad diet of *M. undosa* allows it to thrive in a wide range of habitats and at depths well beyond the *Macrocystis* kelp forest.

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In Mission Bay, large numbers of *M. undosa* were found with BD of less than 55 mm living among calcareous coralline algae which is also consumed by larger snails over a wide range of depths. Based on A/E % data, Mazariegos-Villarreal *et al*. (2017) commented on the low food value of the coralline species. Although it is speculation, is it possible that the snails benefit more from the ingestion of the calcareous structure of the coralline algae than the consumption of the live plant tissue?

Reproduction – Development Review. Gluyas-Millán *et al.* (2000) found the sex ratios were approximately 1:1. Males were slightly larger than females of the same age class and location. They suggested the difference might be attributed to females putting more energy into gonadal development rather than shell development. Cupul-Magana & Torres-Moye (1996), and Schwalm (1973) also reported a sex ratio of approximately 1:1.

Martone & Micheli (2012) evaluated monthly growth rates, age classes and gonad development in two populations in different oceanic environments. Bahia Tortugas (27°678'N -114°919'W) is an area of persistent upwelling, while Punta Abreojos (26°707'N-113°579'W) is further south, with weak upwelling and warmer water. To the north, sexually mature snails had BDs of 50-60 mm while in the south they matured at 60-70 mm BD. After age class three, the mean BD of shells were significantly larger in the south but they reported reduced fecundity in the warmer water. The first notable increase in fecundity over smaller individuals was among snails with a BD of 60-80 mm.

Belmar-Pérez *et al.* (1991) and Belmar-Pérez & Guzmán-del Próo (1992) examined gonadal development of *M. undosa* and found peak reproductive activity occurred from the fall to early spring, but low levels of reproductive activity were reported throughout the year. The extent of reproductive activity varied yearly, and may be influenced by water temperature, depth, and maturity of the snails. Males tended to congregate in breeding clusters prior to the females arriving. The species is a broad-cast spawner. The gonads of the male are ivory in color while those of the females are green to olive (Belmar-Perez *et al.,* 1991, Gluyas-Millán *et al.*, 1999).

Guzman *et al*. (2003) spawned *M. undosa* in the laboratory and both described and illustrated the development from the fertilized egg to the juvenile snail at day 70. On day five the pelagic larvae settle out of the water column, but it was not until day 9 that they entered the post larval stage and displayed well developed eyes. Juvenile shell development began at day 30, with shell pigmentation at day 45; they continued to document development to day 70. During their developmental study the water temperature was 17- 20° C. In laboratory studies Catton, 2005 tested the development of eggs at five-degree increments from 10 to 25° C, and found cleavage in the eggs to be abnormal at only the lowest temperature. Development in the fertilized eggs was normal and accelerated at progressively higher temperatures within the parameters of the study.

The length of time in the planktonic stage is an important factor influencing dispersal and connectivity within a geographic area. Higher water temperatures in BCS may shorten developmental time and therefore the duration in the planktonic stage, which in turn may contribute to less connectivity in warmer waters. Haupt *et al.* (2013) reviewed mtDNA patterns from 17 locations along the length of this species' distribution. They found the northern population were genetically more homogeneous, while portions of the southern population were

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far more genetically diverse with many haplotypes, indicating that gene exchange from south to north, is not robust. They also discussed historic fluctuations in oceanic conditions and how it may influence genetic connectivity and suggest that the reduced genetic variability of the northern population may be the result of founder's effect resulting from reinvasion of the area after the last period of glaciation.

Temperature Tolerance. In a laboratory study Diaz *et al.* (2011) determined that at 29.7 °C (85.7° F) 50 % of the *M. undosa* tested could no longer grip the surface with their foot, an LD_{50} was not determined**.** Gluyas-Millán *et al.* (2002) reviewed the impact of an El Niño event (1997-98) in the northern portion of BCS where ocean temperatures reached 27 °C, nearly 4 °C higher than normal. They observed increased mortality among *M. undosa*, a significant decrease in snail biomass, and a 26.5 % reduction in annual catch. They attributed the elevated mortality and reduced biomass to starvation resulting from the loss of the giant kelp *Macrocystis pyrifera.* Considering the diverse diet of this herbivore, many of the other 30 genera of algae they are known to consume must have also been negatively affected. During the 2016 El Niño, surface water temperatures in Mission Bay reached 27 °C. Below three meters the water was 25 °C. Both *M. pyrifera* and *E. menziesii* were temporarily lost in Mission Bay, but increased mortality or other obvious changes in the *M. undosa* population was not observed.

Commercial Fishery. The commercial fishery for *Megastraea* started in BCS in 1980. A report from the Secretary of Agriculture, Livestock, Rural Development, Fisheries and Food (Item 11, *Megastraea*. 2018) summarizes the commercial fisheries of México from 2000-2016. An estimated average of 200 tons of *Megastraea* muscle was harvested in BCS annually; the average catch in BC was approximately 49 tons/year. A decline of the yearly catch began in BCS in 2011 and in BC during 2013. The report does not indicate if the reduced catch was driven by market demand or a depletion of the population. Biologists in México provide recommendations to fishing cooperatives regarding the regional catch. A 20% annual take of the legal sized individuals is the guideline used for annual quotas (Item 11, *Megastraea*. 2018).

The California fishery began in 1992, but initially the catch was placed in the miscellaneous category by California Fish and Wildlife. In 1996 the catch was reported separately as "Snail Top." Table 4 presents California Fish and Wildlife data for the commercial landing of *Megastraea* and price per pound (in shell). The annual value of the harvest in southern California has fluctuated greatly as has the pounds harvested, with record landings from 1998 to 2000. It is likely that competition from the Mexican fishery and market demand combine to make *Megastraea* a marginal fishery in southern California. A summary of the yearly commercial catch in California (Table 4.) indicates approximately 89.6 tons (gross weight) was harvested off southern California between 1996 and 2019; of that 74.8 % (67 tons gross) was harvested off San Diego. California Fish and Wildlife has not updated their on-line commercial catch records since 2019.

California, has no minimum size limit for sport or commercial take. As such, the size (BD) of the snails harvested is unknown. Graph 2 shows the correlation between grams of edible muscle and shell BD for *M. undosa* from San Diego. For snails with a BD of 80 mm or greater the average weight of the edible muscle was 15.5 % of the gross weight (STD 2.12, n = 59). Based on that data, the 67 tons (gross) from the San

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Diego area may have yielded approximately 10.5 tons of edible muscle during the past 24 years. Compared to BC and BCS, with a combined average commercial catch of 249 tons of edible muscle annually, the historic catch from southern California is miniscule, but so is the habitat off San Diego.

Although the muscle weight of *M. undosa* and *M. turbanica* are combined in Baja catch data, each species has a different size limit. The minimum legal size for *M. undosa* is a basal diameter of 90 mm, while the minimum BD for *M. turbanica* is 100 mm. In México, the commercial season is closed from November 1st to February 28th (Item 11, *Megastraea*. 2018).

California, has no size limit or closed season for the commercial landings, nor a distinction between either species of *Megastraea*. Management of this low value fishery has not been a priority in California. Strong compliance with the Marine Protected Areas (MPA) and other types of marine conservations areas protects large tracks of habitat off San Diego. Interim regulations were proposed in a 2001 report by the California Fish and Game (Appendix A, 2001) which included a size limit, closed season, and limiting the number of "participants" in the fishery, but no action was taken.

In the recent past, the authors conducted a series of transects off Isla Coronado del Norte, BC. The target areas had similar rock habitat and the depth averaged 14-16 m. At that Island, *M. undosa* has been collected by commercial divers as part of a fishery. All *Megastraea* observed, were typically under 75 mm BD. As such, the population of *Megastraea* must be supported by reproductively active snails far too small to be of value. Martone & Michell (2012) evaluated factors that influence growth and reproduction of *M. undosa* on a regional basis. They found that snails with basal diameters between 60 to 80 mm exhibit the first notable increase in fecundity, over smaller individuals.

Densities in the study area off Coronado del Norte were as follows; *Pomaulax gibberosus* (Dillwyn, 1817) 0.736 m^2, *M. turbanica* 0.186 m^2 and *M. undosa* 0.171 m^2. At Isla San Geronimo, BC, Rodríguez-Valencia *et al*. (2002) surveyed a *Megastraea* population that had been depleted by commercial harvesting. They reported the mean size of *M. undosa* at 60 mm with a density of 0.1 m^2. The mean size of the few *M. turbanica* found was 57 mm with a density of 0.006 m^2. Their study included 101 transects at various depths. They attribute the small mean size and low density to fishing practices.

Knowing the relationship between BD and age, plus the population structure, an estimate of the portion of the population protected from harvest may be made if a minimum size limit is applied. Further, information regarding age-based fecundity allows adjustment to the size limit that may sustain the commercial catch. Unexpected changes in age class distribution may point to years of poor or highly successful recruitment.

Summary

The *in situ* diet of *Megastraea undosa* is known to include at least 30 genera of marine algae. The occurrence of *M. undosa* is not restricted to the presence of giant kelp *Macrocystis pyrifera.* Juveniles age classes are often missing from off-shore surveys. Juveniles are not cryptic or hidden; they are commonly found in shallow water associated with coralline algae on rocks or patches of dense eel grass. Mature *M. undosa* with BD exceeding 130 mm off San Diego are age class 13 or greater. Very large *M. undosa*

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are uncommon but, the BD can reach 150 mm and are likely age class 15.

A small commercial fishery has existed in southern California since 1996. Most fishery related research on *Megastraea* has been conducted on the Baja California peninsula, with a focus on diet, growth, and reproduction. In Baja California there are size limits for both species of *Megastraea*, a closed season during part of the reproductive cycle and established annual quotas for the various fishing zones. In California, there is no size limit, closed season or bag limit. Approximately 75 % of the California commercial catch has been taken from San Diego. Approximately 15.5 % of the gross weight (animal and shell) is edible muscle. Shells in the area of San Diego can be aged based on table 2, such data combined with additional sampling can be used to estimate the population structure at different depths and habitat.

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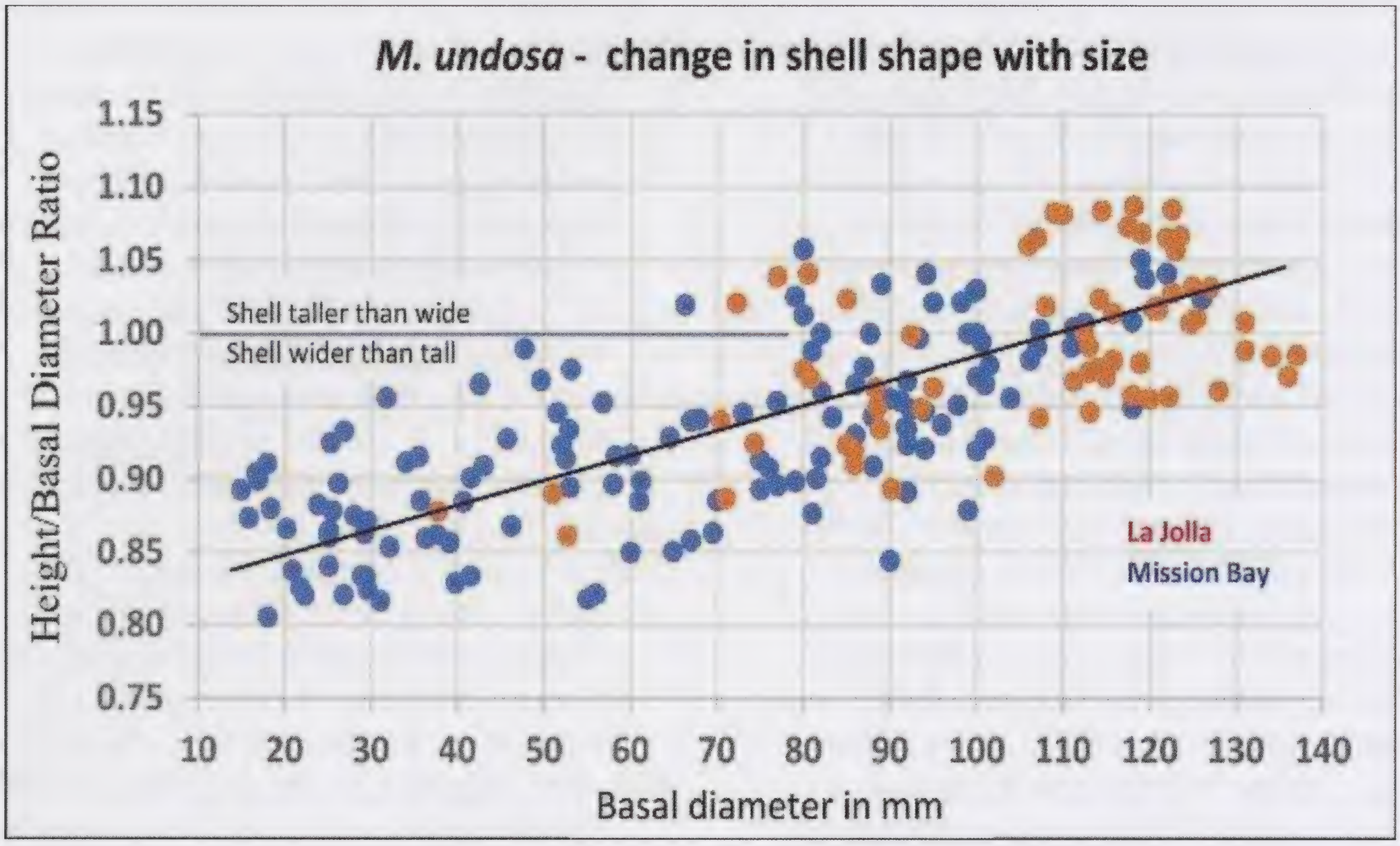
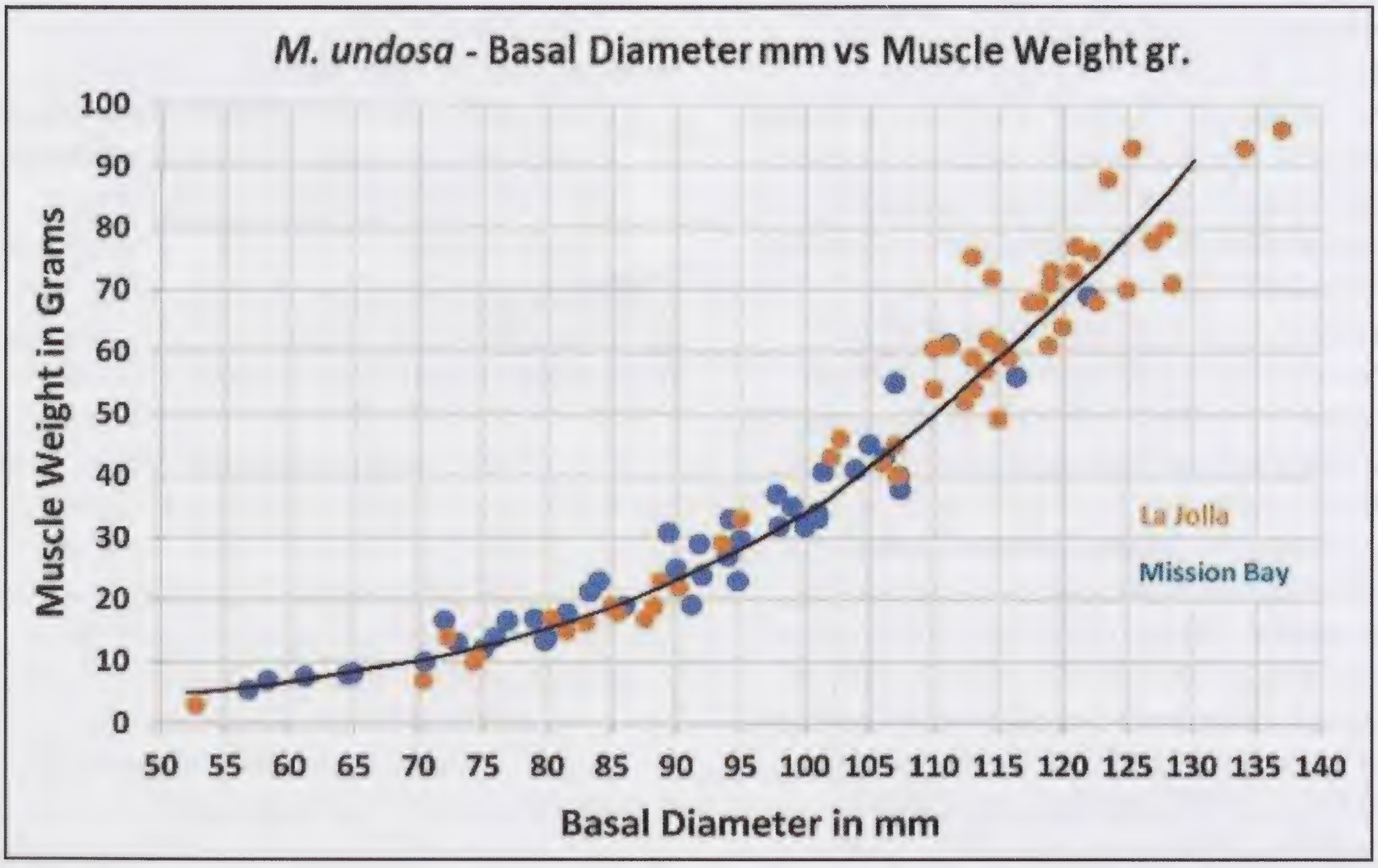


Graph 1. The ratio of height to basal diameter (H/BD). When the ratio is greater than one, the height is greater than width. When the ratio is less than one the shell is wider than the height. Over time the shell of *Megastraea undosa* elongates with age.



Graph 2. Edible muscle weight (grs) vs. shell basal diameter (mm) of *M. undosa*. The chart may be used to estimate muscle weight for various size individuals. One once equals 28.4 grams.

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Age	*M. undosa* - Mission Bay Operculum Length mm			*M. undosa* - La Jolla Operculum Length mm			P value
	Avg	STD	Range	Avg	STD	Range	P <0.05
1	5.7	0.57	4.7-6.6	6.2	0.71	5.5-7.2	P <0.05
2	9.6	0.76	8.2-10.5	9.7	0.54	8.5-10.6	P <0.05
3	12.7	0.81	11.3-13.8	12.8	0.71	11.2-13.8	P <0.05
4	16.2	1.01	14.1-17.5	16.0	1.32	14.3-19.2	P <0.05
5	19.9	1.32	17.8-22.2	19.6	1.34	18-22.5	P <0.05
6	23.9	1.46	22.4-24.8	23.8	1.54	21.7-26.3	P <0.05
7	27.8	1.35	26-31.3	27.7	1.75	26-30.5	P <0.05
8	32.2	1.06	29-33.4	32.4	1.73	30.5-37	P <0.05
9	35.8	1.15	33.8-38.1	36.6	1.34	36-38	P <0.05
10	39.7	1.80	38-42.2	40.9	2.13	39.7-43.2	P <0.05
11	44.0	1.75	41.5-47	44.2	1.16	44.2-48.3	P <0.05
12	49.9	1.41	49.7-51.9	49.4	1.47	47-51.4	P <0.05
13	--	--		52.9	1.11	51.7-54.7	n/a
14	--	--		56.6	--	56.4	n/a

Table 1. Operculum length vs. Age. There was no significant difference between paired age class data for *Megastraea undosa* from Mission Bay and off-shore La Jolla.

Age	*M. undosa* Mission Bay Basal Diameter mm			*M. undosa* La Jolla Basal Diameter mm			*P* value
	Avg	STD	Range	Avg	STD	Range	
1	18.5	2.46	14-22	---	---	---	n/a
2	27.4	2.31	23-32	---	---	---	n/a
3	36.9	3.30	32-42	37.7	---	---	n/a
4	43.8	2.35	42-50	---	---	---	n/a
5	53.7	2.44	47-57	52.7	---	---	n/a
6	60.9	2.91	56-65	---	---	---	n/a
7	72.9	3.39	66-77	73.2	4.28	70-81	*P* <0.05
8	82.1	1.70	79-88	84.5	3.31	80-89	*P* <0.05
9	88.9	2.91	84-92	87.8	2.00	85-91	*P* <0.05
10	96.9	2.53	92-100	99.5	2.64	93-103	*P* <0.05
11	106	3.65	100-112	111.5	3.52	103-115	***P* >0.001**
12	118.9	1.71	116-121	119.8	3.73	113-127	*P* <0.05
13	--	--		128.9	4.89	123-134	n/a
14	--	--		137		137	n/a

Table 2. Age vs. Basal Diameter. *Megastraea undosa,* from Mission Bay and La Jolla. The BD of age class 11 from Mission Bay was significantly smaller than the same age class from La Jolla, yet, at age class 12 the average BD between the two locations varied by only 1.3 mm and was statistically insignificant. n/a = sample size insufficient for statistical analysis.

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Table 3	*M. undosa* Mission B	*M. undosa* La Jolla	*M. undosa* Guadalupe*
Avg BD mm STD	104.9 11.0	117.7 9.3	99.19 5.41
BD range for shells > 90 mm	90 - 121	90 - 137	92 - 126
Avg Height mm STD	102.95 14.10	119.0 12.4	103.83 8.44
Height/Base ratio STD	0.97 0.05	1.01 0.05	0.96 0.04
Sample Size	35	44	29

Table 3. Data from shells with the minimum basal diameter of 90 mm (minimum size limit in México) and greater, from San Diego, CA and Isla Guadalupe BC. * Historic commercially collected shells.

Year	Total lbs	SD catch lbs	Price per lb	SD % of catch
1996	721	721	UK	100
1997	3,618	2,907	0.53	80.3
1998	86,956	63,527	0.40	73.0
1999	24,276	22,494	0.40	92.7
2000	26,152	26,148	0.52	99.9
2001	8,743	8,346	0.61	95.5
2002	1,651	1,200	2.02	72.7
2003	774	664	0.69	85.7
2004	8,375	2,171	0.31	25.9
2005	1,213	745	0.45	61.4
2006	370	0	3.47	0.0
2007	475	172	1.10	36.2
2008	362	65	1.17	17.9
2009	588	155	1.26	26.4
2010	572	48	0.98	8.4
2011	990	303	0.88	43.9
2012	981	351	2.95	35.6
2013	830	670	2.57	80.7
2014	903	875	1.77	96.9
2015	4,144	1,668	1.52	40.0
2016	729	356	2.13	48.8
2017	719	146	2.13	19.7
2018	3,008	118	0.49	3.9
2019	2,035	157	1.03	7.8
Total	**179,185**	**134,007**		**74.8%**

Table 4. Summary of annual landings of Wavy Top Turbans (*Megastraea*) in southern California. Gross weight data provided by the California Dept of Wildlife. SD = San Diego. UK = unknown.

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A New Astraeine Turbinid from the Korean Peninsula with Notes on a New Subprovince of the Japonic Molluscan Province

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ABSTRACT A new species of giant Star Shell (Turbinidae: Astreinae) has been discovered from the Neritic Zone of the Korean Peninsula. The new taxon, *Pomaulax geummiae* new species, is described from specimens collected by Haenyeo women shellfish divers on Jeju Island, South Korea. Based on the range of this new species, and the distributions of other endemic taxa, a new subprovince of the Japonic Molluscan Province, the Korean Subprovince, is described.

KEY WORDS Turbinidae, Astreinae, *Pomaulax*, *P. geummiae, P. japonica,* Korea, Japonic Molluscan Province, Korean Subprovince

INTRODUCTION

The Japonic Molluscan Province is a paratropical region that extends from the east and west coasts of central Honshu Island, Japan, to the Ryukyu Archipelago and the Korean Peninsula, to the Yellow Sea and coast of China, and to Taiwan and the deeper water areas of the central South China Sea (Petuch and Berschauer, 2020: 197, figure 6.2). Within this large warm temperate biogeographical area, the molluscan fauna of the Korean Peninsula stands out as being the least studied within the province. Its biogeographical placement within the Japonic Province is discussed in the following the species description in this paper.

Recently, a collector in South Korea brought to our attention a Star Shell of the genus *Pomaulax* that is the largest-known member of its genus and which is undescribed. Comparable in size to the giant *Megastraea undosa* (Wood, 1828) and *M. turbanica* (Dall, 1910) Star Shells of the Californian Molluscan Province, this distinctive turbinid was collected by the renowned women shellfish divers (Haenyeo) of Jeju Island, South Korea, who collect them as a food resource. Although initially considered to be a variant of the well-known long-spined *Pomaulax japonicus*, enough morphological differences exist to warrant its description as a full species. The new Korean turbinid is described in the systematic section in this paper.

The new species of *Pomaulax* is described in context with the other members of the genus: one from the Western Pacific and two from the Eastern Pacific. The holotype is deposited in the molluscan type collection of the Department of Malacology, Los Angeles County Museum of Natural History, Los Angeles, California and bears an LACM catalog number.

SYSTEMATICS

Class	Gastropoda
Subclass	Vetigastropoda
Order	Trochida
Superfamily	Trochoidea
Family	Turbinidae
Subfamily	Astraeinae
Genus	*Pomaulax* Gray, 1850

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Pomaulax geummiae Berschauer & Petuch, new species
(Plate 1, Figures A-B; Plate 2, Figures A-B)

Description. Shell medium to large for genus, with maximum diameter reaching in excess of 120 mm; thick shelled and solid; spire high, in excess of ninety percent as tall as wide; protoconch yellowish-white and eroded; teleoconch consisting of two to three straight sided whorls sculpted with undulating oblique ribs; body whorl reddish-tan with gold highlights; periphery of early whorls with 12 to 15 flat hollow spines forming a slightly flaring rim at the peripheral edge, increasing in number to 25 to 30 small blunt knobs in later whorls; body whorl sculpted with spiral cords of strong beads which often fuse into undulating cords, with a strong spiral cord of beads just above a rounded peripheral edge; base yellowish-tan, slightly convex, sculpted with 12 to 15 strong spiral beaded cords; umbilicus closed, smooth, white, with a central depression over the umbilical area; aperture rounded and elongate, silvery nacreous interior; operculum smooth, white, elongate, thick and heavy with medium tan to light brown peripheral edge.

Type Material. HOLOTYPE - LACM 3325, measuring 106.9 mm in height, 112.8 mm in width. PARATYPES - One specimen in the Berschauer collection measuring 107.3 mm in height and 116.7 mm in width; one specimen in the Petuch collection measuring 113.6 mm in height and 120.1 mm in width; one specimen in the Suhan Kim collection measuring 102.0 mm in height and 127.0 mm in width; five specimens in the collection of Andy Tan, measuring between 90.0 and 120.0 mm in height and 100.0 to 127.0 mm in width.

Type Locality. Jeju Island, South Korea. Collected at approximately 30 meters depth.

Range. Known from various locations as far north as Gochang, Jeeollanam-do, South Korea in the Yellow Sea in the west (known as "the West Sea"), across the far south near Jeju Island (in "the South Sea"), to Dokdo and Ulleungdo Islands, in the Korean Strait / southern Sea of Japan on the eastern side of South Korea (in "the East Sea") (Figure 2).

Etymology. Named in honor of Mun Geum Mi, a traditional woman free diver and shellfish gatherer ("Haenyeo") of Jeju Island, South Korea, who collected the type specimens.

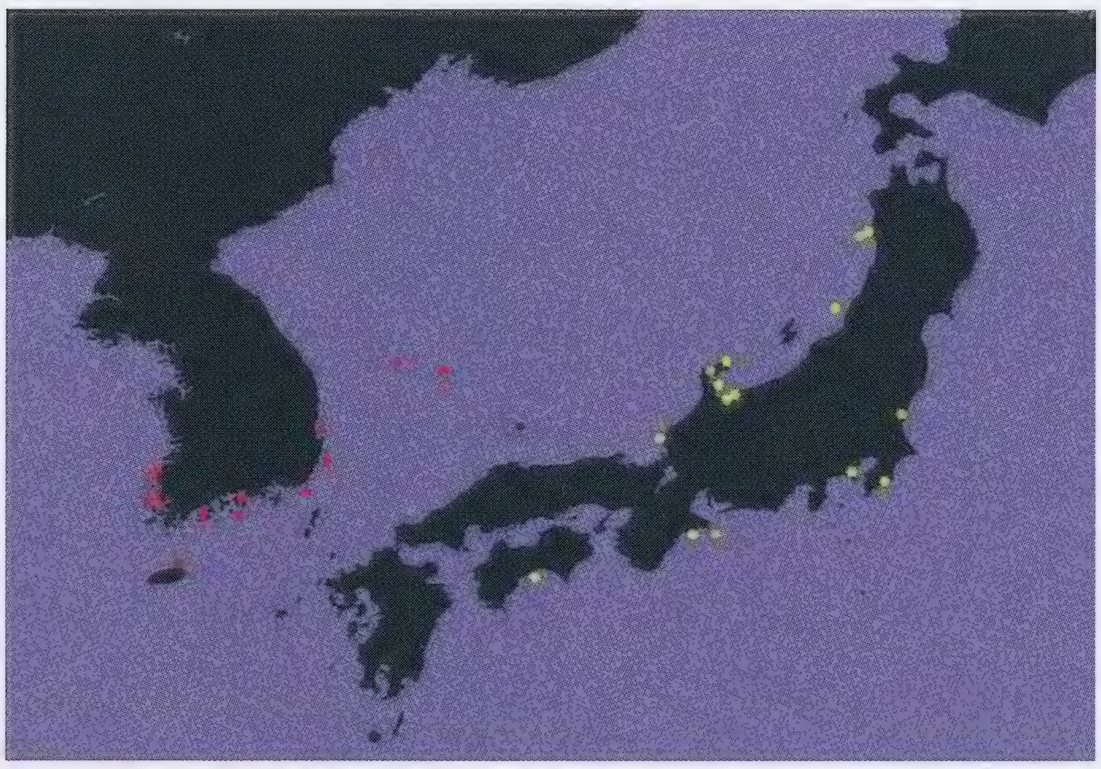

Figure 1. Map showing the ranges and distributions of the two Japonic Province *Pomaulax* species. Yellow dots represent verifiable records of *P. japonicus*. Red dots represent verifiable records of *P. geummiae* from GBIF records from Kwon, 2022.

Discussion. This new species is most similar to the Japanese Archipelago *Pomaulax japonica* (Dunker, 1844), the related taxon to which it has previously been referred. *Pomaulax geummiae* differs in having a proportionately higher spire, heavier shell, more numerous smaller peripheral knobs (25 to 30 in *P. geummiae*, compared to 11 to 12 in *P. japonica*), a rounded peripheral edge, and stronger ornamentation on the body whorl and base. The new species is restricted to the Korean Subprovince of the Japonic Province (described below) and is known only along the southern end of the Korean Peninsula in South Korea and on adjacent offshore islands such as

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Jeju. The closely-related *P. japonica* is found only along the islands of Honshu and Shikoku on the Japanese mainland and is not reported to range any farther west or south (the known ranges of the two related taxa are shown here on Figure 1; see GBIF Secretariat, 2022). The morphological differences in body shape between these two Japonic species, are shown in a regression analysis of height to width ratios, which are readily apparent on the graph in Figure 3.

As presently understood, the North Pacific Ocean genus *Pomaulax* is represented by four living species (shown here on Plate 3). These include:

Pomaulax geummiae Berschauer and Petuch, new species (Plate 3, Figure A), here described from South Korea and Jeju Island.

Pomaulax spiratus (Dall, 1911) (Plate 3, Figure B); southern tip of Baja California Sur and the southern Gulf of California (records of this species from Costa Rica and Ecuador are erroneous).

Pomaulax gibberosus (Dillwyn, 1817) (Plate 3, Figure C); British Columbia, Canada to central Baja California, Mexico.

Pomaulax japonicus (Dunker, 1844) (Plate 3, Figure D); eastern and western coasts of Honshu Island, Japan and the eastern coast of Shikoku Island, Japan.

Of these four known *Pomaulax* taxa, *P. geummiae* is the largest species, reaching a size that dwarfs the other congeners. Along with the Californian *Megastraea* species (*M. undosa* and *M. turbanica*), the new Korean endemic *Pomaulax* is among the largest of the worldwide astreine turbinids. For a review of the more well known *Pomaulax* taxa, see Alf & Kreipl (2011).

BIOGEOGRAPHICAL FRAMEWORK

In our worldwide marine biogeographical treatment, Tropical Marine Mollusks: An Illustrated Biogeographical Guide (2020), we recognized three biogeographical subprovinces of the Japonic Province; the **Shikokuan Subprovince** (the southern half of Honshu Island, and Shikoku and Kyushu Islands of mainland Japan); the **Ryukyuan Subprovince** (the Ryukyu Archipelago and East China Sea islands); and the **South China Subprovince** (Taiwan, the Taiwan Straits, and deep water areas of the South China Sea). Although sharing most of the classic widespread Japonic index species (Petuch and Berschauer, 2020: 196-199), these three areas also have their own assemblages of regional endemic species, all at a level of endemism that exceeds 25% of the total molluscan fauna.

Until recently, little was known about the malacofauna of the Yellow Sea and Korean coasts, primarily due to regional political problems and lack of field workers in the area. Sporadic collecting by commercial shell collectors and dealers has recently brought to light several new or rarely-seen species and subspecies, all of which are now known to be endemic to the Korean Peninsula and adjacent Yellow Sea. Some of these include the muricid *Ceratostoma burnetti coreanica* (A, Adams, 1854), the babyloniids *Babylonia habei* Altena and Gittenberger, 1981 and *Babylonia perforata* (Sowerby II, 1870), the buccinid *Neptunea dilatata* (Yen, 1936), and the new astreine turbinid *P. geummiae* described above. These taxa, and others from the Korean Peninsula and Yellow Sea region, demonstrate that the malacofauna of this area constitutes a previously-unnamed subdivision of the Japonic Province. The composition of the typical Japonic molluscan fauna is defined and described in Petuch and Berschauer, 2020.

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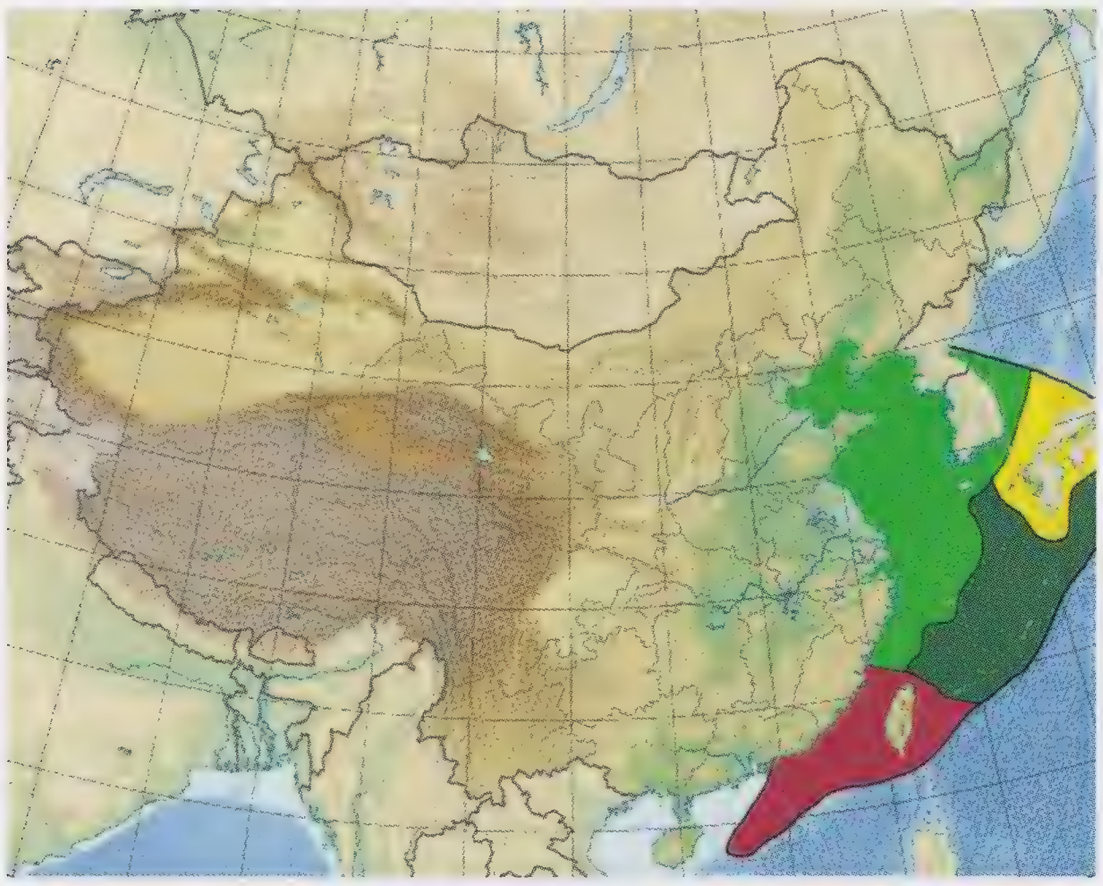

Figure 2. Map of the Japonic Province showing the coastlines of North Korea, South Korea, China, and the Yellow Sea: the Shikokuan Subprovince (yellow), the Ryukyuan Subprovince (dark green), the South China Subprovince (red), and the **Korean Subprovince** (light green).

In our 2020 book, we lacked sufficient biodiversity data to be able to assign a biogeographical name to the Korean and Yellow Sea areas. Consequently, we left this area of the Japonic Province unnamed, stating that the undifferentiated area on our biogeographical map "demarcates environments with cooler water temperatures that support impoverished Japonic-type faunas; these may eventually prove to be a new subprovince" (Petuch and Berschauer, 2020: 197, figure 6.2). The discovery of this new Korean turbinid lends support to the differentiation of the area shown here on the map in Figure 2 (in light green) as a new fourth subprovince within the Japonic Province. We here name this new biogeographical subdivision the **Korean Subprovince**, which includes the Korean Peninsula, the entire Yellow Sea, and the central coast of China. For a thorough review of the intertidal fauna of Korean Subprovince see Ryu *et al.* 2012, Noseworthy *et al.* 2007, and Noseworthy & Kwang-Sik 2010.

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The authors thank Andy Tan for bringing this new taxon to their attention, and thank Suhan Kim for providing the type lot of *Pomaulax geummiae*, which was collected by the renowned women shellfish divers (Haenyeo) of Jeju Island, South Korea. Thanks are also given to Lindsey Groves of the Natural History Museum of Los Angeles County, Malacology Department for providing measurements of *Pomaulax japonicus* in the museum's collection (LACM 151836), and to Paul Tuskes and Don Pisor for providing measurements of two *Pomaulax japonicus* specimens in the collection of Don Pisor.

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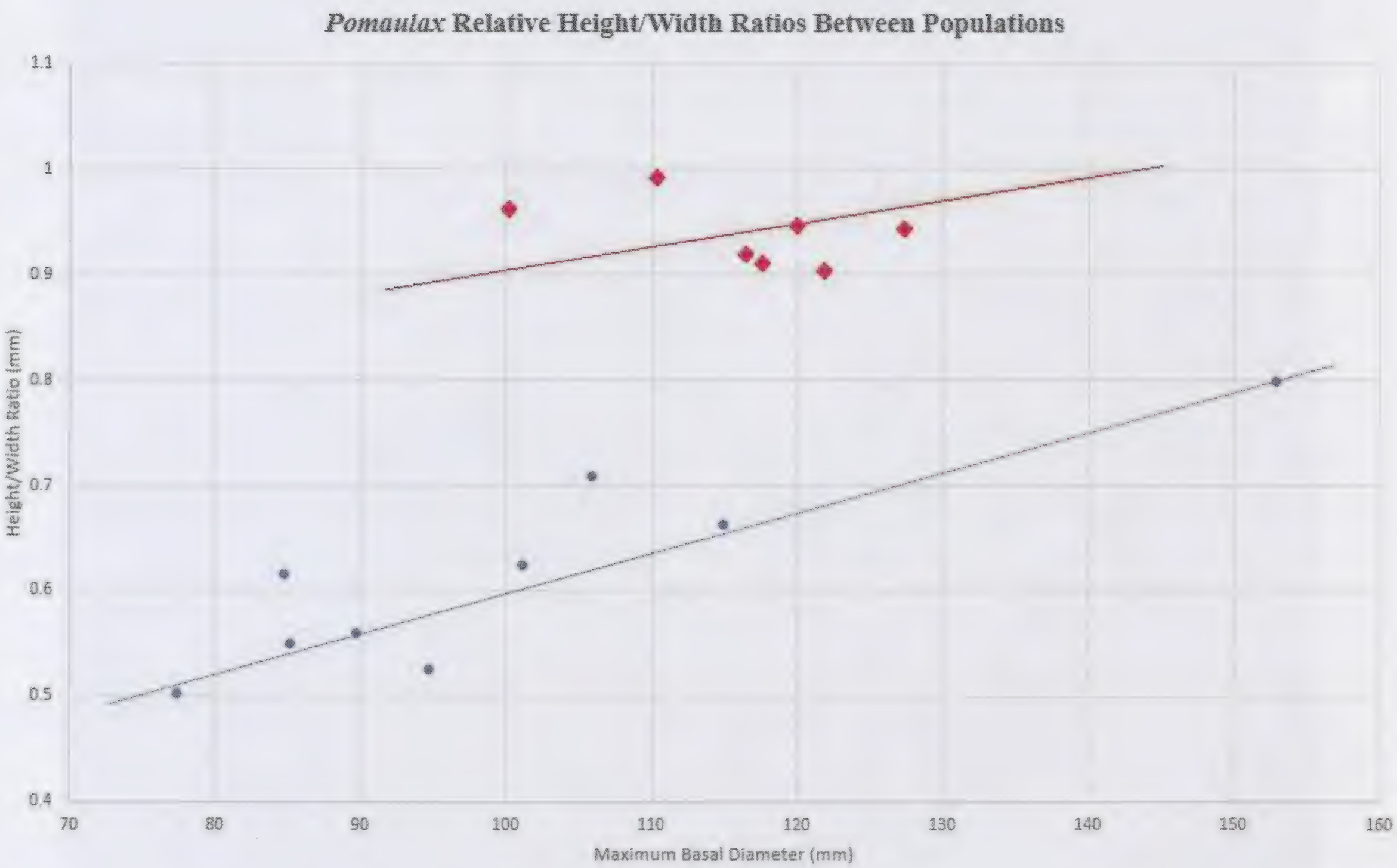

Figure 3. Graph showing the relative height to width ratios of studied specimens of the two Japonic *Pomaulax* species. Blue dots and line = height/width ratios of *Pomaulax japonicus*. Red diamonds and line = height/width ratios of *Pomaulax geummiae* n. sp. As seen here, there is no overlap in the shell profiles of the two related taxa.

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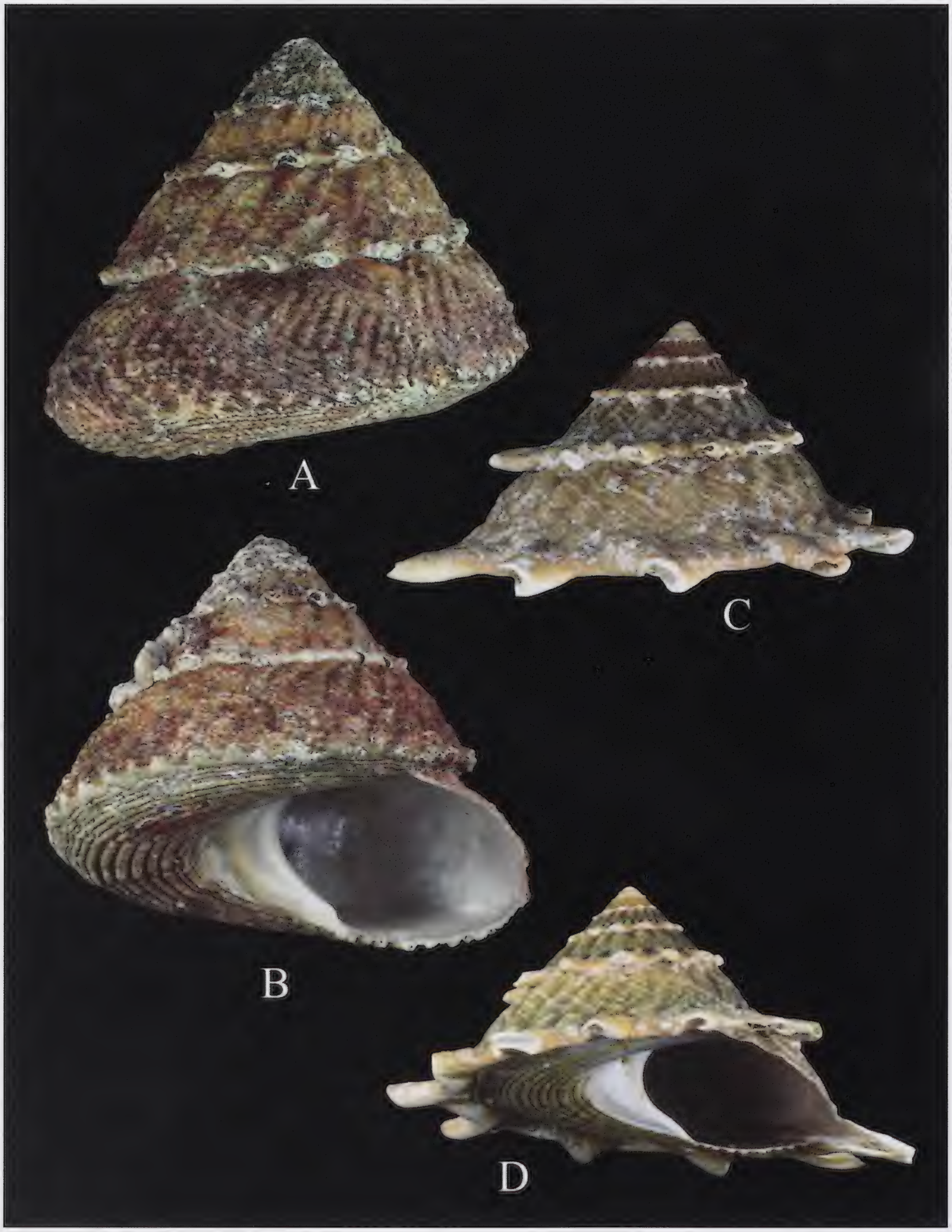

Plate 1. *Pomaulax* species from the Japonic Province.
A, B= *Pomaulax geummiae* Berschauer and Petuch, new species. Holotype, height 106.9 mm, width 112.8 mm, LACM 3325. Collected in 30 m depth off Jeju Island, South Korea, by the Haenyeo, Mun Geum Mi; **C, D**= *Pomaulax japonicus* (Dunker, 1844. height 46.8 mm, width 85.3 mm collected in deep water off Point Daio, Honshu, Japan.

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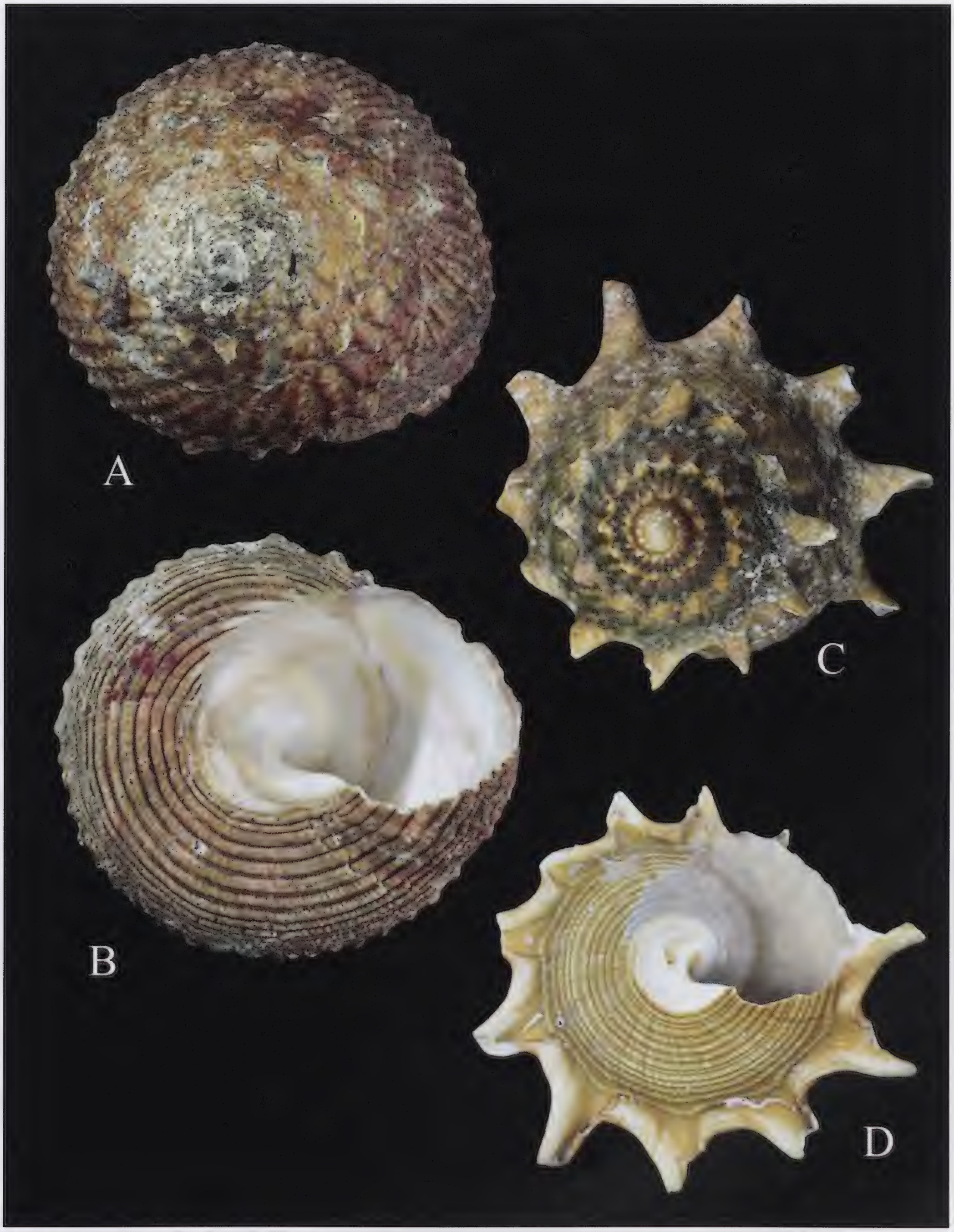

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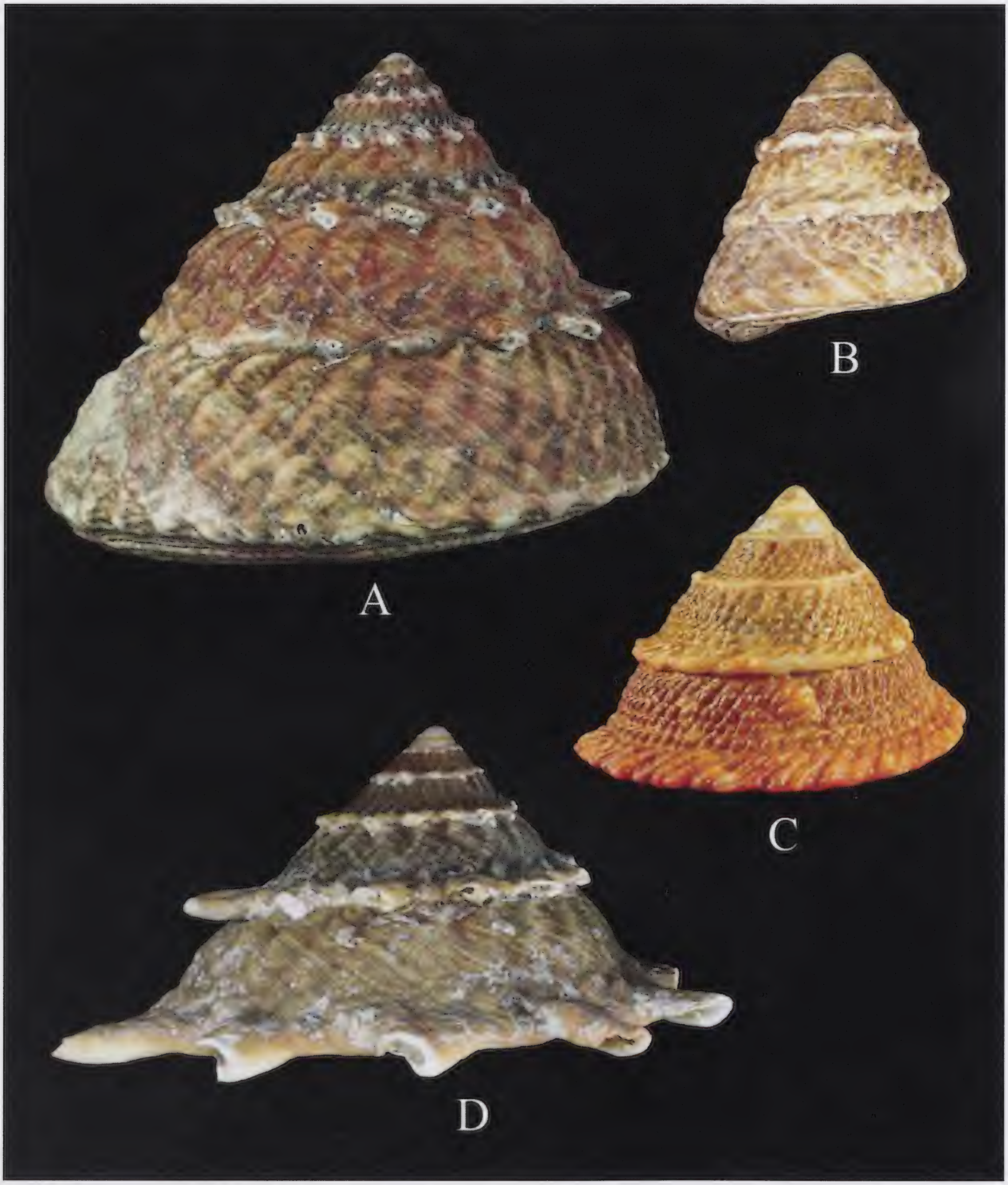

Plate 3. *Pomaulax* species from the Eastern and Western Pacific.
A= *Pomaulax geummiae* Petuch and Berschauer, new species; height 107.3 mm, width 116.7 mm, off Jeju Island, South Korea; **B**= *Pomaulax spiratus* (Dall, 1911); Holotype USNM 222318, approximate height 31.0 mm, width 29.6 mm, type locality unknown but based upon recently collected specimens presumed to be near Cabo San Lucas, Baja California Sur, Mexico; **C**= *Pomaulax gibberosus* (Dillwyn, 1817); height 40.3 mm, width 45.1 mm, collected at 65 feet off Point Loma, San Diego, California (Paul Tuskes Collection); **D**= *Pomaulax japonicus* (Dunker, 1844); height 46.8 mm, width 85.3 mm, Point Daio, Honshu, Japan.

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Volume: 55 THE FESTIVUS ISSUE 1

Species of the Families Costellariidae and Mitridae Dredged by the R/V *Pelican* in the Gulf of Mexico

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ABSTRACT This paper reports 12 species of Costellariidae and 6 species of Mitridae dredged by the R/V *Pelican* in the Gulf of Mexico off the coasts of Louisiana, Mississippi, Alabama, Florida and Bahía de Campeche, Mexico, between 1996 and 2019. Each species is accompanied by accurate coordinates and depth and, in most cases, benthic composition.

KEYWORDS Gulf of Mexico, Costellariidae, Mitridae, geographic distribution, habitat

INTRODUCTION

This is a continuing report of species collected by the R/V *Pelican* between 1996 and 2019 in the Gulf of Mexico (hereinafter abbreviated as "GOM"). The Family Costellariidae is represented by 12 species: 1 species in the genus *Latiromitra*, 1 in *Mitromica,* and 12 in *Vexillum*. The Family Mitridae is represented by 6 species: 1 in *Dibaphimitra,* 3 in *Isara*, 1 in *Neotiara,* and 1 in *Subcancilla*; the latter, an undescribed species, is the first Recent species of that genus recorded in the GOM.

A number of the dredged samples consist of single specimens. This taxonomic paucity is due to the rarity of the species, usually because they inhabit very deep water, or because most *Pelican* stations were from water deeper than the normal species habitat. Most of the sampling took place off Louisiana, with five "short" expeditions to Alabama and Mississippi, five to Florida and one to Bahía de Campeche, Mexico; therefore, the Louisiana molluscan fauna is the best represented. On the other hand, the three-week, single campaign in Campeche yielded a number of new finds, and added 17 % to the number of species recorded from the southwestern quadrant of the GOM (Rosenberg *et al.*, 2009).

SYSTEMATICS

List in alphabetical order by genus of the families Costellariidae and Mitridae:

Family Costellariidae McDonald, 1860

Latiromitra niveobabelis García, 2015 (Figure 1) - The genus *Latiromitra* had been traditionally placed in the family *Ptychatractidae*, but more recent studies consider it to be better placed in *Costellariidae*. A single specimen of this species was dredged off FLORIDA: 25°51.104'N, 84°52.278'W, in 1737 m, in rubble/mud.

Mitromica foveata (Sowerby, 1874) (Figure 2) - The westernmost record for this species is 89.7° N (Rosenberg, 2009); this find extends its western geographical distribution. MEXICO: 21°51.32'N, 92°03.68'W, in 66-68 m, in mud/shells; 20°52.40'N, 92°24.83'W, in 77-81 m in mud.

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Vexillum articulatum (Reeve, 1845) (Figure 3) - This species is similar to *V. histrio* (Reeve, 1844), with which it has been confused in the past (see García, 2011). It has also been confused with *V. pulchellum*; figures 3-3a in Tunnell *et al.* (2010:228), identified as *V. puchellum,* are *V. articulatum*. FLORIDA: 24º37.51'N, 83º36.57'W, in 70.4-93.4 m; 24º48.61'N, 83º40.59'W, in 65.9-66.6 m; 24º48.929'N, 83º40.609'W, in 65 m, in rubble and crushed shells. LOUISIANA: 27º57.599'N, 92º02.619'W, in 67 m, in rubble; 28º05.793'N, 91º01.607'W, in 56-57 m, in rubble; 28º05.945'N, 91º02.163'W, in 53.8-56.1 m, in rubble; 28º05.845'N, 91º01.817'W, in 54-58 m, in rubble; 28º05.605'N, 91º01.778'W, in 57 m, in rubble; 28º05.54'N, 91º01.38'W, in 54.8-56.6 m, in rubble.

Vexillum epiphaneum (Rehder, 1943) (Figure 4) - FLORIDA: 25º01.354'N, 83º43.559'W, in 82-85 m, in rubble. LOUISIANA: 28º 03.439'N, 92º 26.978'W, in 71-74 m, in calcareous rubble; 28º06.066'N; 91º02.418'W, in 57-65 m, in calcareous rubble; 28º05.760'N, 91º01.147'W, 64.7-62.1 m, in rubble; 28º05.508'N, 91º01.611;W, in 56m, in fine rubble.

Vexillum garciai Salisbury & Wolff, 2009 (Figure 5) - This previously undescribed species was dredged at three stations in Bahía de Campeche, MEXICO: 20º52.40'N, 92º24.83'W, in 77-81 m, in mud; 20º51.49'N, 92º21.44'W, in 63-65 m, in mud; 20°00.35'N, 92°26.10'W, 73-77 m, in mud.

Vexillum hendersoni (Dall, 1927) (Figure 6) - Dredged only as single specimen, it was collected alive only once. FLORIDA: 27º37.16'N, 84º00.32'W, in 57.6-57.6 m. LOUISIANA: 27º 56.358'N, 92º 00.540'W, in 60 m, in calcareous rubble; 28º 03.439'N, 92º 26.978'W, in 71-74 m, in coralline rubble; 28º4.57'N, 90º59.99'W, in 87.9 m; 28º4.57'N, 90º59.99'W, in 87.9 m; 28º38.16'N, 89º33.19'W, in 60-70 m; 28º03.71'N, 92º27.77'W, in 59-62 m, in medium-size rubble, alive; 28º03.44'N, 92º27.32'W, in 65-73 m, in rubble/mud; 28º37.85'N, 89º33.23'W, in 63.3-66 m; 27º51.103'N, 92º55.180'W, in 75-108 m, in sediment; 27º59.28'N, 91º39.28'W, in 77-79 m, in rubble. MEXICO: 20º50.22'N, 92º18.91'W, in 53 m, in mud; 20°00.35'N, 92°26.10'W, 73-77 m, in mud.

Vexillum cf. hendersoni (Dall, 1927) (Figure 7) - This may be an abnormal specimen of *V. hendersoni* but, besides different coloration, it has more numerous axial ribs. LOUISIANA: 27º59.28'N, 91º39.28'W, in 77-79 m, in rubble.

Vexillum moniliferum (C. B. Adams, 1850) (Figure 8) - Although Rosenberg (2009) reports this species from the Florida Keys, Rosenberg *et al.* (2009) do not record it from the GOM. This seems to be the only confirmed record from the GOM. MEXICO: 20°39.66'N , 91°57.09'W, in 29-33 m.

Vexillum pulchellum (Reeve, 1844) (Figure 9) - Before the *Pelican* findings, this species had been reported in the GOM only from the Florida Keys (Rosenberg, 2009). Figures 3-3a in Tunnell *et al.* (2010:228), identified as *V. puchellum,* are *V. articulatum*. FLORIDA: 29º43.08'N, 85º53.16'W, in 39-38.7 m. LOUISIANA: 27º53.418'N 93º18.219'W, in 50-65 m, in calcareous rubble; 27º58.947'N, 91º39.382'W, in 66-79 m, in rubble.

Vexillum styria (Dall, 1889) (Figure 10) - Only poorly preserved specimens were collected; before the *Pelican* findings, records from Louisiana had not been previously reported. ALABAMA: 29º21'N, 87º42'W, in 140 m; 29º28'N, 87º27.30'W, in 173 m. FLORIDA: 27º 34' N; 84º 30' W, in 140 m, in rubble/sand; 27º48.62'N, 84º45.80'W, in 205-210.5 m.

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LOUISIANA: 27°53.65'N, 91°21.48'W, in 219-221 m, in mud. MEXICO: 22°16.28'N, 91°30.42'W, in 107-108, in mud.

Vexillum sykesi (Melvill, 1925) (Figure 11) - This was the most commonly dredged costellariid in the Louisiana offshore banks. FLORIDA: 24°59.14'N, 83°39.39'W, in 71.7-73.0 m; 27°42.20'N, 84°10.25'W, in 57.5-57.9 m; 24°58.61'N, 83°39.28'W, in 75.8-76.8 m; 28°55.45'N, 85°09.20'W, in 54 m. LOUISIANA: 27°48.7'N, 93°02.88'W, in 55-65 m; 27°54.895' N 92° 22.594' W, in 60 m, in calcareous rubble; 28°05.897'N 91°02.169'W, in 56 m, in calcareous rubble; 27° 59.141'N, 91° 38.832'W, in 91-65 m in calcareous rubble/sponges; 28°06.066'N, 91°02.418'W, in 57-65 m, in calcareous rubble; 28°5.85'N, 91°1.28'W, in 68.3 m; 28°38.16'N, 89°33.19'W, in 60-70 m; 28°36.905'N, 89°32.658'W, in 65-80 m; 28°44.76'N, 90°14.15'W, in 27-28 m, in rubble /sponges; 28°05.041'N, 91°01.648'W, in 70-75 m, in rubble. MEXICO: 20°39.59'N, 91°57.06'W, in 30-31 m, in rubble/sponges/gorgonian; 22°08.04'N, 91°23.67'W, in 52-53 m, in rubble; 22°10.42'N, 91°09.55'W, in 46-48 m, in rubble.

Vexillum variatum (Reeve, 1845) (Figure 12) - This Campeche specimen is the first record of the species from the GOM. MEXICO: 22°19.42'N, 90°21.84'W, in 54-49 m, in rubble.

Vexillum wandoense (Holmes, 1859) (Figure 13) - A widely spread species, but dredged at only two stations in west Florida, perhaps due to its small size and shallower habitat. FLORIDA: 27° 37'N, 83° 46' W, in 40 m; 27°42.71'n, 84°13.09'W, in 68- 68.5 m.

Family *Mitridae* Swainson, 1831

Dibaphimitra florida (Gould, 1856) (Figure 14) - Only two empty specimens were dredged off Dry Tortugas. FLORIDA: 24°35.36'N, 83°24.62'W, in 64.0-64.1 m, in rubble & sand; 24°58.70'N, 83°39.23'W, in 75.9-76.1 m.

Isara antillensis (Dall, 1889) (Figure 15) - Also reported from Texas (Tunnell *et al.*, 2010: 229), it is a rare species in the northern GOM. LOUISIANA: 27° 49.24N 92° 53.71W, in 75-85 m, in calcareous rubble; 27°59.189'N, 91°39.466'W, in 77-79 m, in rubble; 28°08.534'N, 90°53.517'W, in 100 m, in mud; 27°53.711'N, 91°21.506'W, in 120 m; rocks/ lg. rubble; 27°55.14'N, 92°22.71'W, in 168-160 m.

Isara straminea (A. Adams, 1853) (Figure 16) - Considered to be a rare species, it seems to live in large colonies in mud bottom. The figured specimen is one of some twelve specimens collected alive in the same dredge haul. ALABAMA: 29°21'N.; 87°42'W, in 140 m; 29°15.512'N, 88°20.269'W, in 85 m, in shelly mud. LOUISIANA: 28°38.06'N; 89°33.13'W, in 66 m; 28°06.975'N; 90°58.150'W, in 89-92 m, in mud, alive, common; 28°38.16'N, 89°33.19'W, in 60-70 m; 28°37.327'N, 89°33.046'W, in 77-85 m; 28°03.080'N, 91°58.641'W, in 101-100 m, in mud; 28°05.068'N, 91°11.360'W, in 110 m, in packed mud; 27°49.34'N, 93°05.92'W, in 195-196 m; 27°53.56'N, 91°21.6'W, in 95-95 m; 27°53.65'N, 91°21.48'W, in 219-221 m, in mud.

Isara ulala (García, 2011) (Figures 17-18) - In spite of the frequency with which it was found in Louisiana, it was not found anywhere else in the GOM. LOUISIANA: The species was dredged at 19 stations on calcareous tops of pinnacles between 57 and 100 m. [cf. *Isara lenhilli* (Petuch, 1988) (holotype = USNM 859944) which the author distinguishes on a number of characters including axial sculpture, protoconch structure, isolated locality, etc.]

Neotiara nodulosa (Gmelin, 1791) (Figure 19) - Although commonly dredged on the offshore

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pinnacles of Louisiana, the largest specimen, figured here, measures only 21.2 mm. Tunnell *et al.* (2010:229) report it from Texas, but show only a 7 mm juvenile specimen. ALABAMA: 29°15.00'N, 88°20.77'W, in 80 m, in rubble with gorgonians. FLORIDA: 24°37.51'N, 83°36.57'W, in 70.4- 93.4 m; 28°10.28'N, 84°01.95'W; in 41-41.5 m. LOUISIANA: This species was dredged at 13 stations on top of pinnacles between 55 and 79 m.

Subcancilla sp. (Figure 20) - This was an unexpected find, as no *Subcancilla* had been recorded from the GOM. The greatest depth reported for a western Atlantic *Subcancilla* is 100 m (Rosenberg, 2009). MEXICO: 22° 46.25'N, 9016.52'W, in 350 m, in mud.

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In the paper entitled "Four New Cone Shells from Northern and Central Brazil", one of the four authors of the new taxa, Gregorio Pereira de Queiroz, had his surname misused in the naming of the new species. Due to their lack of knowledge of the formation of compound surnames in Latin cultures, the editors chose the wrong surname, Pereira, to attribute to the four new taxa. The new species, *Jaspidiconus barragrandensis*, *Jaspidiconus tibauensis*, *Dauciconus luizcotoi*, and *Poremskiconus guarapari*, were all attributed to the authors Crabos**, Pomponet, Pereira, and Passos** and are considered *nomina imperfecta*. That should now be changed to Crabos, Pomponet, **Queiroz**, and Passos, and presented as *nomina correcta*. The final and correct taxa should be as follows:

***Jaspidiconus barragrandensis* Crabos, Pomponet, Queiroz, and Passos, 2022**
***Jaspidiconus tibauensis* Crabos, Pomponet, Queiroz, and Passos, 2022**
***Dauciconus luizcotoi* Crabos, Pomponet, Queiroz, and Passos, 2022**
***Poremskiconus guarapari* Crabos, Pomponet, Queiroz, and Passos, 2022**

These changes are submitted as Justifiable Emendations and the name "Pereira" should not be used in any subsequent list of authors for these taxa.

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Plate 1. Figure 1= *Latiromitra niveobabelis* García, 2015, 25°51.104'N, 84°52.278'W, in 1737 m, in rubble/mud, 45.9 mm; **2**=*Mitromica foveata* (Sowerby, 1874), 21°51.32'N, 92°03.68'W, in 66-68 m, in mud/shells, 7.6 mm; **3**= *Vexillum articulatum* (Reeve, 1845), 28°05.793'N, 91°01.607'W, in 56-57 m, in rubble, 22.4 mm; **4**= *Vexillum epiphaneum* (Rehder, 1943), 28° 03.439'N, 92° 26.978'W, in 71-74 m, in calcareous rubble, 26.9 mm; **5**= *Vexillum garciai* Salisbury and Wolff, 2009, 20°51.49'N, 92°21.44'W, in 63-65 m, in mud, 5 mm; **6**=*Vexillum hendersoni* (Dall, 1927), 28°03.71'N, 92°27.7, in 59-62 m, in medium-size rubble, 19.3 mm; **7**= Vexillum cf. *hendersoni* (Dall, 1927), 27°59.28'N, 91°39.28'W, in 77-79 m, in rubble, 15.6 mm; **8**= *Vexillum moniliferum* (C. B. Adams, 1850)- 20°39.66'N ; 91°57.09', in 29-33 m, 16 mm; **9**= *Vexillum pulchellum* (Reeve, 1844), 27°53.418'N 93°18.219'W, in 50-65 m, in calcareous rubble, 16.9 mm; **10**= *Vexillum styria* (Dall, 1889), 27°48.62'N, 84°45.80'W, in 205- 210.5 m, 14 mm.

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Plate 2. Figures 11= *Vexillum sykesi* (Melvill, 1925), 28°05.041'N, 91°01.648'W, in 70-75 m, in rubble, 9.3 mm; **12**= *Vexillum variatum* (Reeve, 1845)- 22°19.42'N, 90°21.84'W, in 54-49 m, in rubble, 20.6 mm; **13**= *Vexillum wandoense* (Holmes, 1859), 27° 37' N., 83° 46' W, in 40 m, 4.6 mm; **14**= *Dibaphimitra florida* (Gould, 1856), 24°58.70'N, 83°39.23'W, in 75.9-76.1 m, 33.5 mm; **15**= *Isara antillensis* (Dall, 1889), 27°59.189'N, 91°39.466'W, in 77-79 m, in rubble, 26.7 mm; **16**= *Isara straminea* (A. Adams, 1853), Diaphus Bank:28°06.975'N; 90°58.150'W- dredged in 89-92 m in mud, 28.3 mm; **17**= *Isara ulala* (García, 2011), holotype, 28°05.95'N, 91°01.34'W, in 69-68 m, in rubble, 30.5 mm; **18**= *Isara ulala,* Jakkula Bank: 27°58.925'N, 91°39.779'W, in 72 m, fine rubble/shell hash; **19**= *Neotiara nodulosa* (Gmelin, 1791), 28°05.605'N, 91°01.778'W to 28°05.360'N, 91°01.674W; 57 m in rubble, 21.2 mm; **20**= Subcancilla sp., 22°46.25'N, 9016.52'W, in 350 m, in mud, 30.4 mm.

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Volume: 55 THE FESTIVUS ISSUE 1

A New Species of *Fasciolaria* (Gastropoda: Fasciolariidae) from Northern South America

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ABSTRACT A new species in the gastropod genus *Fasciolaria* Lamarck, 1799 is described from Venezuela, where it is known to range from the Monges Islands and Gulf of Venezuela eastward to the mouth of the Orinoco River. The new taxon, *Fasciolaria petuchi* n. sp., was previously referred to as the taxon *F. hollisteri* Weisbord, 1962, which is a fossil species from the Pliocene Mare Formation and is not applicable to the living Venezuelan shell. *Fasciolaria petuchi* is the fourth known member of a species complex that ranges from Honduras to the mouth of the Amazon River.

KEY WORDS Fasciolariidae, *Fasciolaria*, Venezuela, Isla Margarita

INTRODUCTION

Along northern South America, from the Panama-Colombia border (Golfo de Uraba) to the mouth of the Amazon River, the gastropod genus *Fasciolaria* Lamarck, 1799 has evolved a complex of at least four distinct, bathymetrically and geographically-isolated species. These include: the widespread Caribbean *Fasciolaria tulipa* (Linnaeus, 1758), which is found only sporadically along northern South America, primarily on offshore islands; *Fasciolaria tephrina* Sousa, 2002, which occurs in deep water from Honduras to the Goajira Peninsula of Colombia; *Fasciolaria guyanensis* Lyons and Snyder, 2016, which ranges from the Orinoco River mouth eastward to the mouth of the Amazon River, Amapa State, Brazil; and a distinctive species that has been incorrectly referred to as "*Fasciolaria hollisteri* Weisbord, 1962", which ranges from the Gulf of Venezuela to the Orinoco River mouth.

In his study of the fossil beds near Cabo Blanco, Venezuela, Weisbord (1962: 353-354) described a new *Fasciolaria* species from the late Pliocene (late Piacenzian Age) Mare Formation (holotype shown here on Plate 1, Figures A-B). Named *Fasciolaria hollisteri*, this distinctive fossil species was found to belong to a Caribbean Pliocene species complex that also included similar taxa such as *F. semistriata* (Sowerby I, 1849) from the Dominican Republic and *F. leura* Woodring, 1928 from Panama. In 1987, Petuch (plate 20, figure 6) illustrated a living *Fasciolaria* specimen from Amuay Bay in the Gulf of Venezuela but referred it to the fossil taxon *F. hollisteri*, as it occurred along with many other relictual and archaic species with late Neogene affinities. Subsequent workers have perpetuated this misidentification, consistently referring to the living species as "*F. hollisteri*". A comparison of the holotype of the Pliocene fossil *F. hollisteri* (shown here on Plate 2, Figure 3) with living specimens from Amauay Bay and Isla Margarita, shows many consistent differences between them, demonstrating that the living species is actually not referable to *F. hollisteri* but represents a new and previously undescribed

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species. This new addition to the Venezuelan molluscan fauna is described here. The holotype is deposited in the molluscan collections of the Museu Nacional do Rio de Janeiro, Rio de Janeiro, Brazil and bears an MNRJ catalog number.

SYSTEMATICS
Class Gastropoda
Subclass Caenogastropoda
Order Neogastropoda
Superfamily Buccinoidea
Family Fasciolariidae
Subfamily Fasciolariinae
Genus *Fasciolaria* Lamarck, 1799

Fasciolaria petuchi Crabos and Queiroz, new species
(Plate 1, Figures A-D; Plate 2, Figures A, B)

Description. Shell of average size for genus, thin, fusiform, elevated, with subscalariform spire whorls; body whorl greatly inflated, globose, with rounded shoulder and sides; body whorl smooth, devoid of any spiral sculpture; suture of spire whorls and body whorl marked with one or two wide, strong, spiral cords; smaller secondary cord sometimes present anterior to the main sutural cord, producing a distinctive sutural collar; aperture wide, flaring, oval in shape; curved columella ornamented with two proportionally large, porcellaneous white, fold-like plicae, with the anterior plication very well developed, roughly 4 times the length of smaller posterior columellar plication; siphonal canal proportionally large, narrow, roughly 1/3 of shell length; protoconch proportionally large, rounded, dome-like, composed of 1 ½ whorls; shell base color variable, ranging from pale blue-gray to pale tan to deep orange (as in holotype); base color overlaid with variable number of thin, evenly-spaced spiral brown lines, varying in number from 16 to 20; siphonal canal devoid of spiral lines; interior of lip ornamented with numerous very fine, closely-packed raised cords; fine cords extend into interior of aperture, becoming obsolete deeper within aperture.

Type Material. HOLOTYPE - length 106.5 mm, width 49 mm, Margarita Island, Venezuela, MNRJ 24487; PARATYPES - length 111.8 mm, width 51.5 mm, same locality as the holotype, in the Crabos collection; 5 specimens, length 109 mm, width 55 mm; length 114 mm, width 99 mm; length 81 mm, width 41 mm; length 113 mm, width 59 mm; length 96 mm, width 49 mm, all from the same locality as the holotype, in the Queiroz collection.

Type Locality. Off Punta de Piedras, Margarita Island, Nueva Esparta State, Venezuela, at 5 meters depth.

Distribution. The new species ranges from the Gulf of Venezuela eastward to the mouth of the Orinoco River, where it prefers depths of 1-40 m.

Etymology. The new taxon honors Dr. Edward J. Petuch, Professor Emeritus in the Department of Geosciences at Florida Atlantic University, in recognition of his numerous important contributions to the malacology of the Caribbean Sea and Brazil. Professor Petuch has also been a mentor to us, and other students of Brazilian malacology, helping us with our scientific writing and offering encouragement with our field work.

Discussion. For the past 46 years, this brightly colored and distinctive Venezuelan fasciolariid has been referred to as "*Fasciolaria hollisteri*" by collectors and specialists in the Fasciolariidae. Petuch (1987) was the first person to illustrate this species, but he used the name for a Venezuelan Pliocene fossil described

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by Weisbord (1962) for this shell instead of giving it a new name. This erroneous assignment of a fossil name for a different living species has persisted up to now. When the fossil *F. hollisteri* and the living *F. petuchi* are compared, as shown here on Plate 2, *Fasciolaria petuchi* can be seen to be a more inflated shell with a more rotund body whorl and a proportionally-lower and less protracted spire. The principal difference between the two species is seen in the structure and form of the columellar plications, which are much larger and better-developed on the living *F. petuchi* than they are on the fossil *F. hollisteri* (Plate 2, Figure C; holotype of *F. hollisteri*).

Although the base color of *F. petuchi* varies from red to orange to blue-gray, the western population from the Gulf of Venezuela contains mostly blue-gray individuals, with red and orange shells being relatively uncommon. Just the opposite occurs in the eastern population, where most individuals are orange or red and blue-gray shells are uncommon. This extreme color difference between populations most probably results from different dietary preferences; with the western populations feeding on bivalves in a muddy quartz sand environment and the eastern populations feeding on bivalves that live in cleaner carbonate sand environments. Orange and tan specimens of *Fasciolaria petuchi* could also be confused with the closely-related *F. guyanensis* Lyons and Snyder, 2016 (Plate 2, Figures D, E) from farther east along the coasts of Guyana, Suriname, French Guiana, and Amapa State, Brazil. That species differs from *F. petuchi* in being a more slender and elongated shell with a higher, more protracted spire and proportionally-longer siphonal canal. Of the living and fossil species, *F. guyanensis* most closely resembles the Pliocene *F. hollisteri* in having a similar long siphonal canal and high spire and the same slender body whorl proportions. The Pliocene *F. hollisteri* is now known to be the common ancestor of the living *F. petuchi* and *F. guyanensis*.

ACKNOWLEDGMENTS

We thank Dr. Alexandre Pimenta, Museu Nacional do Rio de Janeiro, for taking the photographs of the fasciolariids used in this paper. We also thank David P. Berschauer of Cairo, Georgia for making the photo plates of shells used here and for use of the images on Plate, Figures 2 and B.

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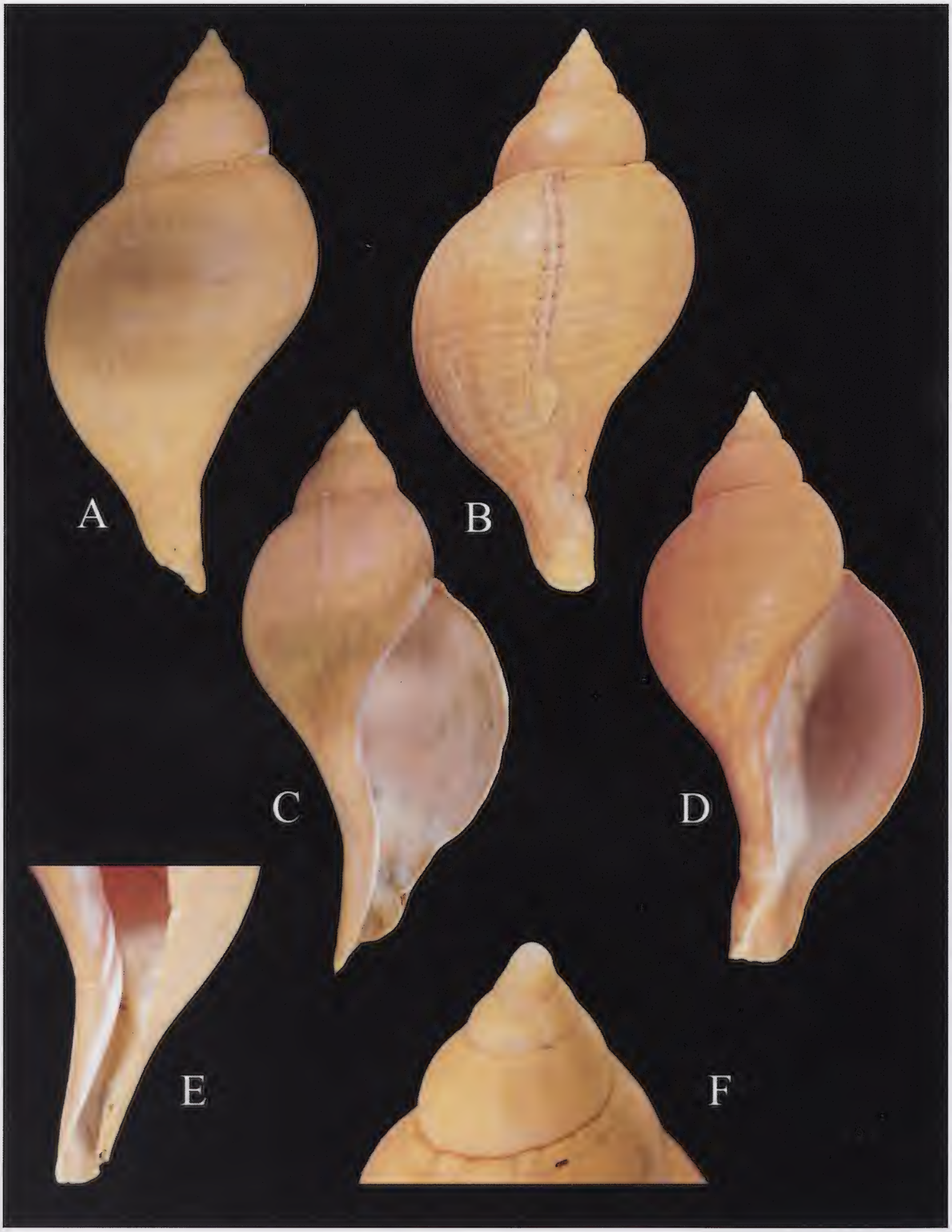

Plate 1. *Fasciolaria petuchi* Crabos and Queiroz, new species.
A, C= dorsal and ventral views of the holotype, length 106.5 mm, from Isla Margarita, Venezuela; **B, D**= dorsal and ventral views of Paratype 1, length 111.8 mm, from Isla Margarita, Venezuela (in the Crabos Collection); **E**= close-up view of the strong columellar plicae of the holotype, which are characteristic of the new species; **F**= close-up view of the protoconch and early whorls of the holotype.

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Plate 2. Living and fossil *Fasciolaria* species from northern South America.
A, B= *Fasciolaria petuchi* Crabos and Queiroz, new species, 173.0 mm in length, specimen of the blue-gray color form from the Gulf of Venezuela (in the Berschauer Collection); **C**= *Fasciolaria hollisteri* Weisbord, 1962, holotype (PRI 26255), length 158.0 mm, from the Mare Formation, late Pliocene (Piacenzian Age), west of Quebrada Mare Abajo,Venezuela (note the lack of prominent columellar plicae on the unique holotype, as opposed to the well-developed plicae on *F. petuchi*); **D, E**= *Fasciolaria guyanensis* Lyons and Snyder, 2016, length 105.0 mm, trawled by shrimpers from 35 m depth off Cayenne, French Guiana (in the Crabos Collection).

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Have a shell collection you would like to donate to The San Diego Shell Club?

The San Diego Shell Club is interested in your shell collection. As a 501c(3) organization, all donations to our Club may provide a tax write-off. When we receive a donation we provide a letter describing the items that may be used when filing your taxes. While we cannot provide a value, donations of up to $5,000 do not require a written appraisal. Since tax laws change regularly we recommend that you check with your tax accountant before relying on any information provided here.

We are interested in all types of shells, marine or land and all genera and species, including books on shells as well as items related to shells such as artwork, storage cases and tools. Your donated items will be used to generate income to support the Club's efforts in continuing Public education about shells and conservation of marine life throughout the world. If you would like to donate, please contact David Waller, SDSC Acquisition Chairperson, by email at dwaller@dbwipmg.com to schedule a time to discuss charitable gifting.

CLUB NEWS

November 2022 - Fall Auction
The Club's annual fall auction was held at the home of Larry and Debbie Catarius was a big success, with excellent attendance and spirited bidding (as always). Many beautiful shells found new homes.

December 2022 - Holiday Party
There was no holiday party this year due to scheduling issues at the intended site.

January 2023 - General Meeting / Show and Swap
On January 21st, the Club held its first in-person general meeting in years, a "Show and Swap with Mini-Auction" at the home of Larry and Toni Buck. Members were encouraged to bring their own shells to show, swap for other shells or sell. David Morikawa brought quite a few of his beautiful shell specimens for the rest of the attendees to look at, and Robyn Waayers brought some shells for sale. There was also a $5 table with groupings of shells from various families available. And the first Mini-Auction offered up 10 beautiful specimens from the recently-acquired Scott Martin Collection, and they all found new appreciative homes! Delicious pizza and home-made brownies were offered and enjoyed and lots of pleasant shell-chat ensued as members caught up with other in person. More such fun in-person meetings are planned for the future. Keep an eye on the Club website Events section for details.

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President's Message

Dear Members,

I am pleased and honored to be elected your President for 2023 and would like to thank you for your support. I would also like to congratulate the other elected members, David P. Berschauer (Vice President), Leo Kempczenski (Recording Secretary), Duffy Daughenbaugh (Treasurer), Robyn Waayer (Corresponding Secretary, Webmaster), Paul Tuskes (Member-at-Large), Roger Clark (Member-at-Large) and Hans Bertsch (Member-at-Large). You have elected an amazing group of individuals for our Board of Directors, and I am excited about what they will accomplish this year.

As we begin the new year, I am pleased to announce that the Club's storage area has be successfully reorganized, the Club's financial reserve is at one of the highest levels in the Club's history following a very successful November auction, and the Club's journal has obtained an impressive "Impact Factor" rating of 0.7 (top 18% of all peer reviewed journals worldwide) and our rating is growing. These were ambitious goals in 2022 and I congratulate the past Board for getting these goals accomplished.

This year the Board has decided to begin scheduling "in-person" General Meetings again as Covid restrictions have eased. They will be structured a little differently than meetings in the past. I anticipate that you will enjoy the new format, so please check the Club's website for the dates and times of our meetings.

In previous President's messages, I have given a brief overview of the Board's goals and objectives for the upcoming year. This year I would like to do something different, I would like to ask our membership to accomplish some goals for our Club in 2023. First, I would like to request that, if you are renewing your membership, then take the time right now, if you have not already done so, and submit your payment. I would also like you to consider attending one or more of our "in-person" meetings scheduled this year and take some time to get to know your Board Members. Finally, I would ask that you challenge your level of commitment to our Club by getting more involved and volunteering on one or more of our many Committees. Your service can be as simple as helping to set up for one of our shell auctions or helping to organize one of the Club's many events throughout the year. Alternatively, you could make a larger commitment by volunteering as a Committee Chairperson or serving as a Member-at-Large on the Board. I know that these types of contributions are more easily achieved if you reside in southern California. However, for those of you who reside elsewhere in the World, you may consider preparing and submitting journal articles for publication in *The Festivus*. These can be scientific articles or articles of general interest. You may consider helping by preparing event fliers and e-mailing them to our membership or helping with the continued development of the Club's website. Whatever level you choose, your contribution will be greatly appreciated.

Thank you again for your support. I wish all our members a safe and prosperous New Year.

David D. Waller

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Glenn E. Burghardt
(May 24, 1933 - December 22, 2022)

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It is with great sadness that I report the passing of yet another great shelling icon. Mr. Glenn E. Burghardt. Glenn was born in Merced, California and raised in Oakland, California, and attended Fremont High school, where he met his wife and soul mate, Laura. Together they embarked on their lifelong journey. They shared a great of love nature, and in the 1960's they began collecting shells and particularly chitons, and in 1969 Glenn along with Laura wrote the iconic book "West Coast Chitons" which inspired generations of biologists and shell collectors. Glenn was also very fond of Muricidae and other groups of mollusks. In the late 1960's and early 1970's while a working as a fish biologist at the Steinhart Aquarium, California Academy of Sciences, Glenn was active in the Santa Barbara Malacological Society and the Western Society of Malacologists. Glenn was a wonderful & generous person and a great friend! He will be greatly missed!

Along with the chiton book, Glenn (often with Laura) wrote numerous articles in Of Sea and Shore and of publications, and described a new species of chiton from the Hawaiian Islands, *Rhyssoplax linsleyi* Burghardt, 1973. In 2000, a chiton was named in honor of Glenn and Laura, *Acathachitona burghardtae* Clark, 2000.

Glenn was preceded in death by his beloved Laura, who passed in May of 2022. He is survived by Michael Burghardt (son), Patricia Ordway (daughter), Kathleen Burghardt-Cobb (daughter), Glen Cobb (son-in-law), grandchildren: Stefanie Tolleson, TJ Tolleson (grandson-in-law), Karilyn Ward, Josh Ward (grandson-in-law), Jeffrey Burghardt, Chad Burghardt, Toneille Burghardt (granddaughter-in-law), Ryan Burghardt, Jon Aether, and Mitchell Cobb. Great grandchildren: Kaili Ward, Jorianna Tolleson, Joanne Tolleson, Logan Burghardt and Clark Burghardt.

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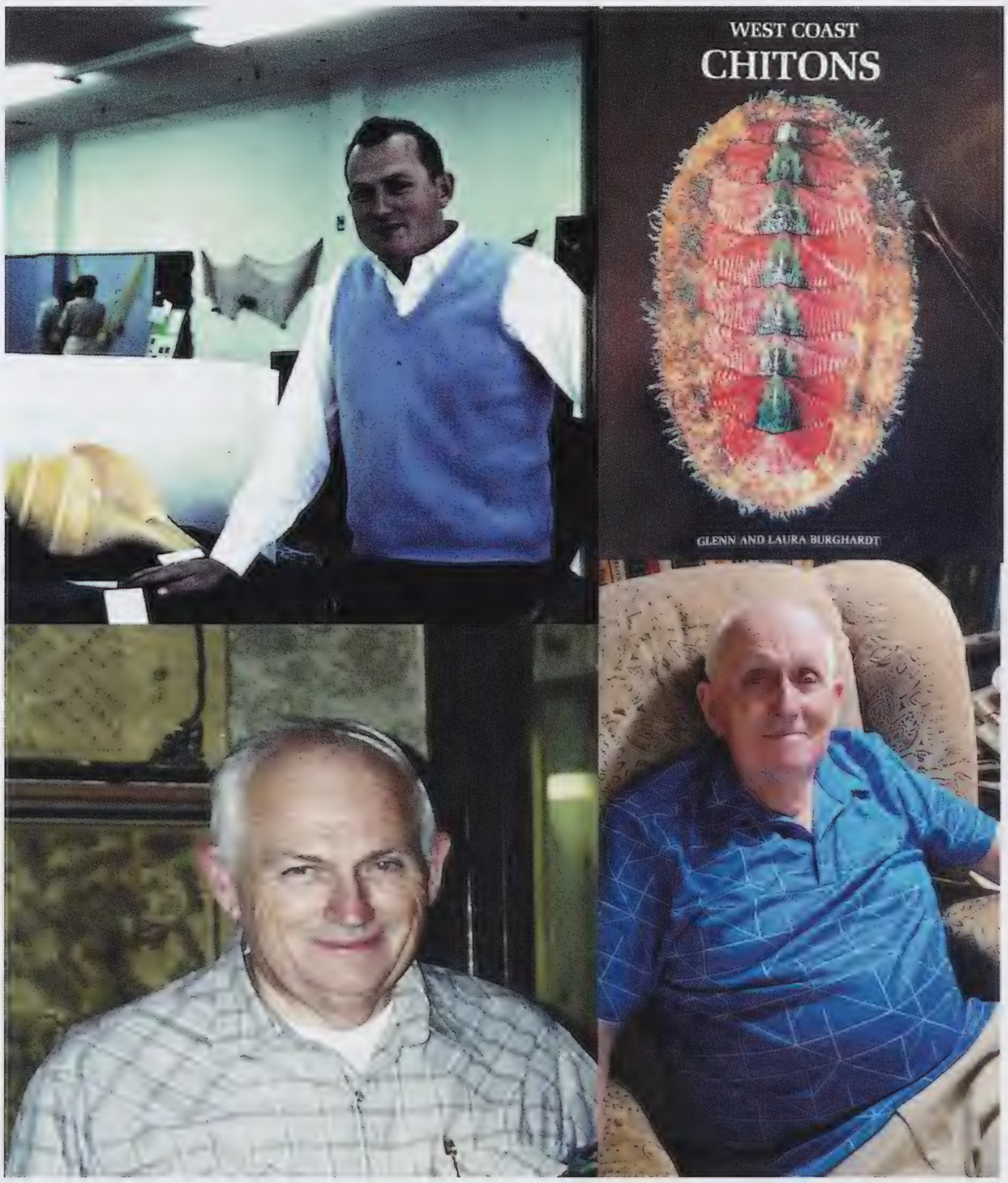

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Divine Sea Slugs: Eponymous Nudibranchs of Hawaiian Goddesses

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Ice and fire. Snow-covered volcanic mountains. Multiple traditional legends of the native Hawaiians speak of two powerful women associated with them: the Goddess of Snow, Poli‘ahu, and the Goddess of Fire, Madame Pele. My favorite is their fight.

It is said that Poli‘ahu loved to compete with mortals in games of chance and skill on the cliffs of the Big Island. Once she and her companions were competing in an hōlua (sledding) contest on the slopes of Mauna Kea and a beautiful stranger appeared among them. She was invited to participate, but then, throwing off all disguise, Pele revealed herself and called for the forces of fire to burst open the doors of the subterranean caverns of Mauna Kea. On top of the mountain she marshaled her fire-fountains, sending streams of molten rock downs the flank of Mauna Kea. In fear, Poli‘ahu fled toward the summit, protecting her snow as Pele’s fiery wrath was beginning to singe its edges. Lava flowed and snow fell as the battle raged on. Poli‘ahu succeeded in pushing Pele’s rivers of lava down into empty tubes and caverns deep within the island. Today there is a “Cold War” co-existence. Mauna Kea and the northern half of the island remain free of eruptions, but Pele continues to grow Mauna Loa on the southern half of the island.

Figure 1. Poli‘ahu Heiau, eastern Kauai (by HB, 1978)

Both ladies have been and still are revered among the Kānaka Maoli (Native Hawaiians). Today the stone walls of heiau (sacred temples) dedicated to Pele and Poli‘ahu can be found deep in the forests (Figure 1). Hula dances and songs are still performed in their honor. (See Nimmo, 1990, Bishop Mus. Occas. Papers 30; https://dlnr.hawaii.gov/ dsp/files/2019/05/Poliahu-Brochure.pdf; and Mauna Kea Education & Awareness, www.mkea.info).

Just a few months ago, on 27 November 2022, the world’s largest volcano erupted again on the Big Island of Hawai‘i. Although traffic was disrupted across the island (see Romero, 2022), the flows did not reach the ocean, and no new land was added to the shoreline.

Geology and biology define this chain of islands stretching some 2700 km across the mid-Pacific. They mark the movement of the Pacific Plate over a hot spot. By land and sea, their biology

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vividly shows speciation in action by isolation and natural selection. Even Charles Darwin commented to Joseph Dalton Hooker in 1850, that he would help pay the expenses of a collector "for a good flora of the Sandwich Islands."

Projecting upwards from the midst of abyssal plains, these oceanic mountains form bathyal and subtidal habitats, where a rich diversity of marine molluscs have evolved (Kay, 1979, and Hoover, 1998). Numerous species of Nudipleura gastropods have been named from these islands (see e.g., Kay & Young, 1969; Gosliner, 1979; Bertsch & Johnson, 1982; and Bertsch & Gosliner, 1989). On their Website (http://seaslugsofhawaii.com) Pittman and Fiene illustrate nearly 350 named and undescribed species of Nudipleura from this region.

Two species of nudibranchs honor the Goddesses Pele and Poli'ahu. A brief description of each species follows.

Nudipleura – Nudibranchia – Chromodorididae

Ardeadoris poliahu (Bertsch & Gosliner, 1989)

Body translucent tan to light orange with many tiny, slightly raised white flecks on the notum. Highly convoluted white mantle margin, edged with yellow-orange. The rhinophores and gills are tan to cream, with longitudinal rust-orange lines. Reaches 57 mm in length. Occurs in moderately protected to highly exposed locations at depths of 3-72 m. It lays a ruffled, cream egg mass, and vibrates its gills. Reliably reported throughout the main Hawaiian Islands (the Big Island, Oahu, Maui, Kauai, Lanai and Niihau). Type locality off the Lanai Lookout, Oahu.

When it was first encountered, this unnamed animal was provisionally called "snowflake," calling attention to the white frosting of snow-like specks on its dorsum (Bertsch & Johnson, 1981). Hence it was appropriate to name the species after the Hawaiian Goddess of Snow.

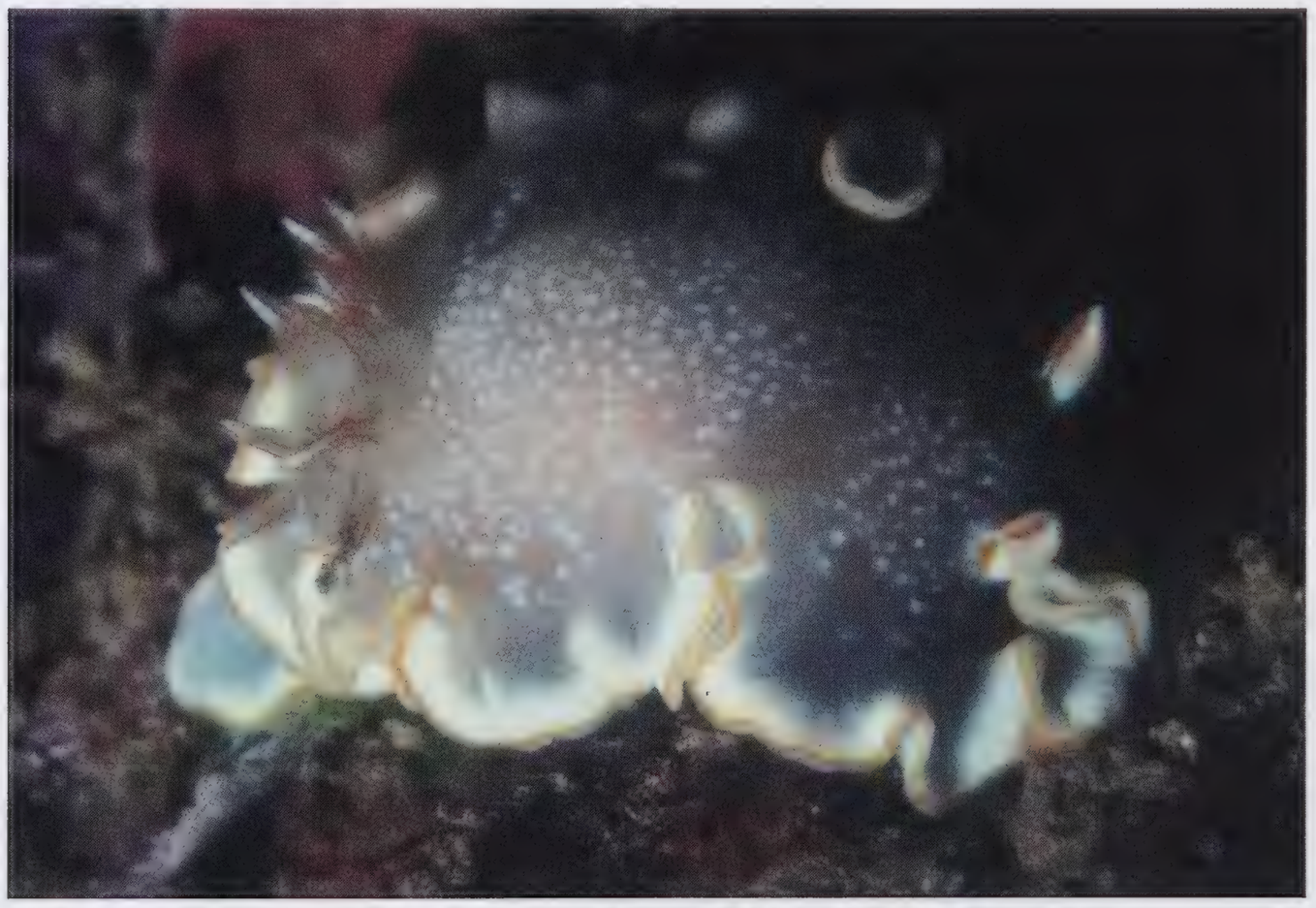

Figure 2. *Ardeadoris poliahu*, ~25 mm, Three Tables, Oahu, 10 m (6 August 1981, HB)

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Bornellidae

Bornella pele Pola, Rudman & Gosliner, 2009

Body translucent-white, dusted with white flecks. Splashes of scarlet occur on the head, the inside of the rhinophoral sheaths, the cerata and the posterior end of the notum. Each ceras bears three projections in addition to the gills. Body length about 19 mm. Found along basalt cliffs in highly exposed locations, from the low intertidal to 6 m. Swims with a side-to-side body movement. Type locality Molokini Island, Hawaii. Known also from the Hawaiian Big Island, Maui and Kahoolawe, and from Japan, Australia, Moorea and Reunion.

Figure 3. *Bornella pele*, 15 mm, Kahoolawe, 21 Jan. 1992 (Photo by Pauline Fiene) http://seaslugsofhawaii.com

"This species is named after the Hawaiian goddess 'Pele,' goddess of fire, lightning, dance, volcanoes and violence. This species was first collected in Hawaii and the red markings of the animal remind [sic] the fire and violence of the Hawaiian goddess" (Pola *et al*., 2009: 34).

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The Upper Size Range of *Acteocina culcitella* (Gould, 1853)

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While the size of a record shell may be of interest, a size list from a large sample often provides a better understanding of what determines a large specimen within a given species. The following list records the greatest measurable dimension of all specimens 20 mm or larger from a sample of 109 specimens of *Acteocina culcitella* (Gould, 1853), collected from San Pedro, California, to Monterey, CA, during the years of 1976 through 1980. All the shells were collected dead, while diving at 8 to 20 meters, by the author. The measured specimens numbered 59, or 54% of the sample. Years ago, I parted with over 160 *A. culcitella* specimens which were smaller overall than those I kept, leaving an admittedly oversized sample in my collection.

James McLean, 1978, gave the geographical range of *A. culcitella* from Kodiak Island, Alaska, to San Ignacio Lagoon, central Baja California, with a height of 8-22 mm, "smaller sizes most frequent." David P. Berschauer and Roger N. Clark, 2018, gave the geographical range from Northern California to central Baja California, Mexico, with a size to 22 mm (at p. 104).

The largest sample specimen, 33 mm, collected off San Pedro, CA, in 1977, was the 1980 and 1987 Lost Operculum Club record and the 1997 through at least 2016 Registry of World Record Size Shells record. *Acteocina culcitella* measuring 24.1 and 25.2 mm were also found off San Pedro in 1979. A new record may lurk near Monterey, CA, where 28, 28.4, 28.4, 31.4, 32, 32.1, and 32.2 mm specimens were collected in December 1979. The area near Flat Rock, off northern Palos Verdes, accounted for 35 specimens, 20 mm or larger, collected from April 1977 through October 1978. The largest Flat Rock shells measured 23.7, 23.8, 23.9, 23.9, 24, 24.7, and 27.2 mm. A 24.7 mm specimen was collected at Torrance Beach in 1976 and nearby Redondo Beach provided 23.6, 24.1, 24.4, and 25.5 mm shells in 1978 and 1979. Twenty-four specimens measured 23 mm or larger, or 22% of the sample and eleven shells or 10% were over 25 mm. Five *Acteocina culcitella* specimens measured over 30 mm – all very large specimens.

Figure 1. *Acteocina culcitella* (Gould, 1853). **A, B** = 33 mm, San Pedro, California; **C** = 33 mm compared to 23 mm specimen. Photos by Paul Stillians.

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Data set for *Acteocina culcitella* (Gould, 1853) specimens 20 mm or larger (from a sample of 109):

33 (largest)	25.5	23.8	21.9 (n=2)	20.9
32.2	25.2	23.7	21.8	20.6 (n=2)
32.1	24.7 (n=2)	23.6	21.6 (n=2)	20.4 (n=2)
32.0	24.5	23.0	21.4 (n=3)	20.2
31.4	24.4	22.5	21.3	20.1
28.4 (n=2)	24.1 (n=2)	22.3	21.2 (n=2)	20 (n=5)
28.0	24.0	22.2 (n=3)	21.1	
27.2	23.9 (n=2)	22.0	21.0 (n=5)	

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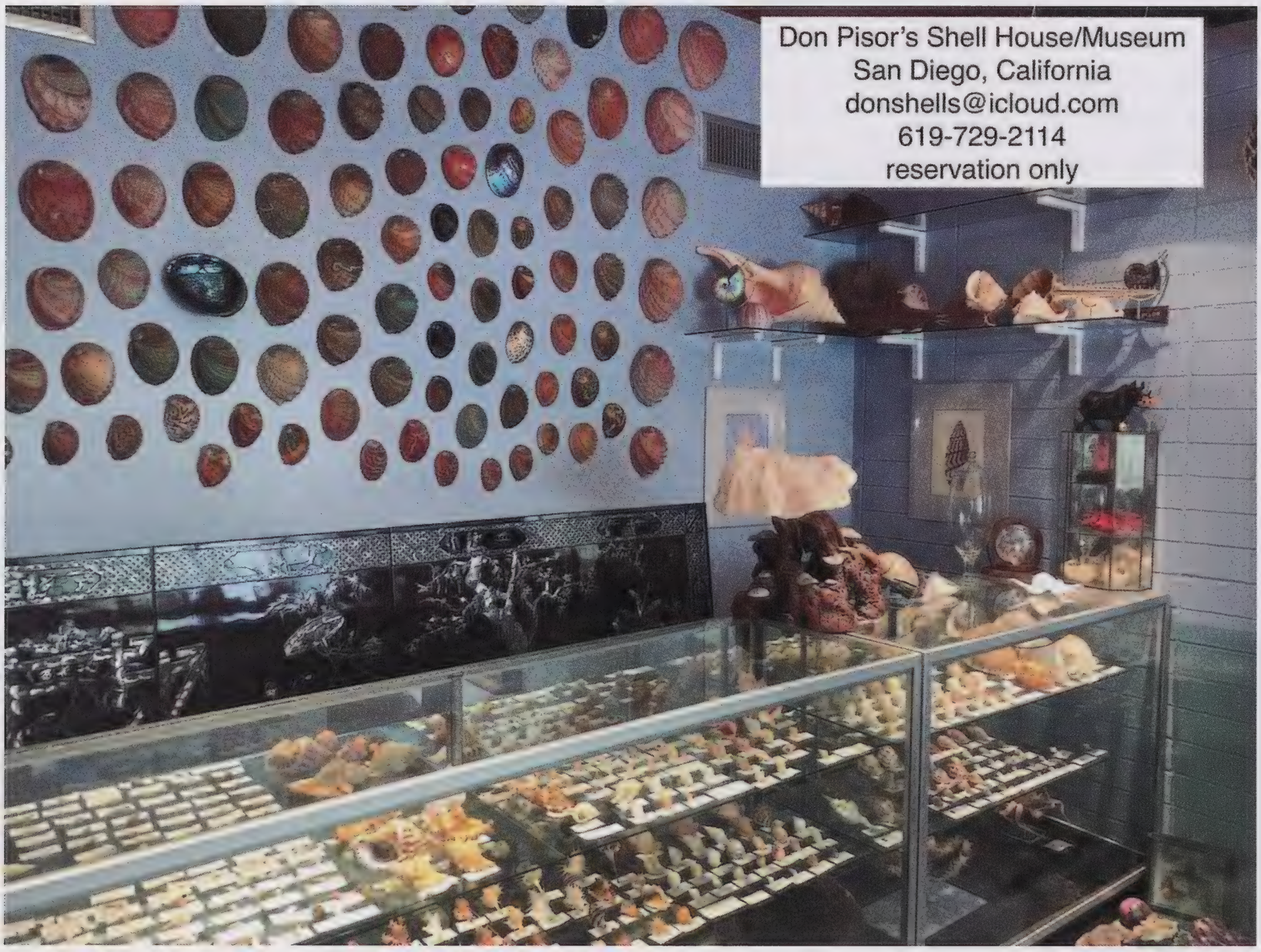

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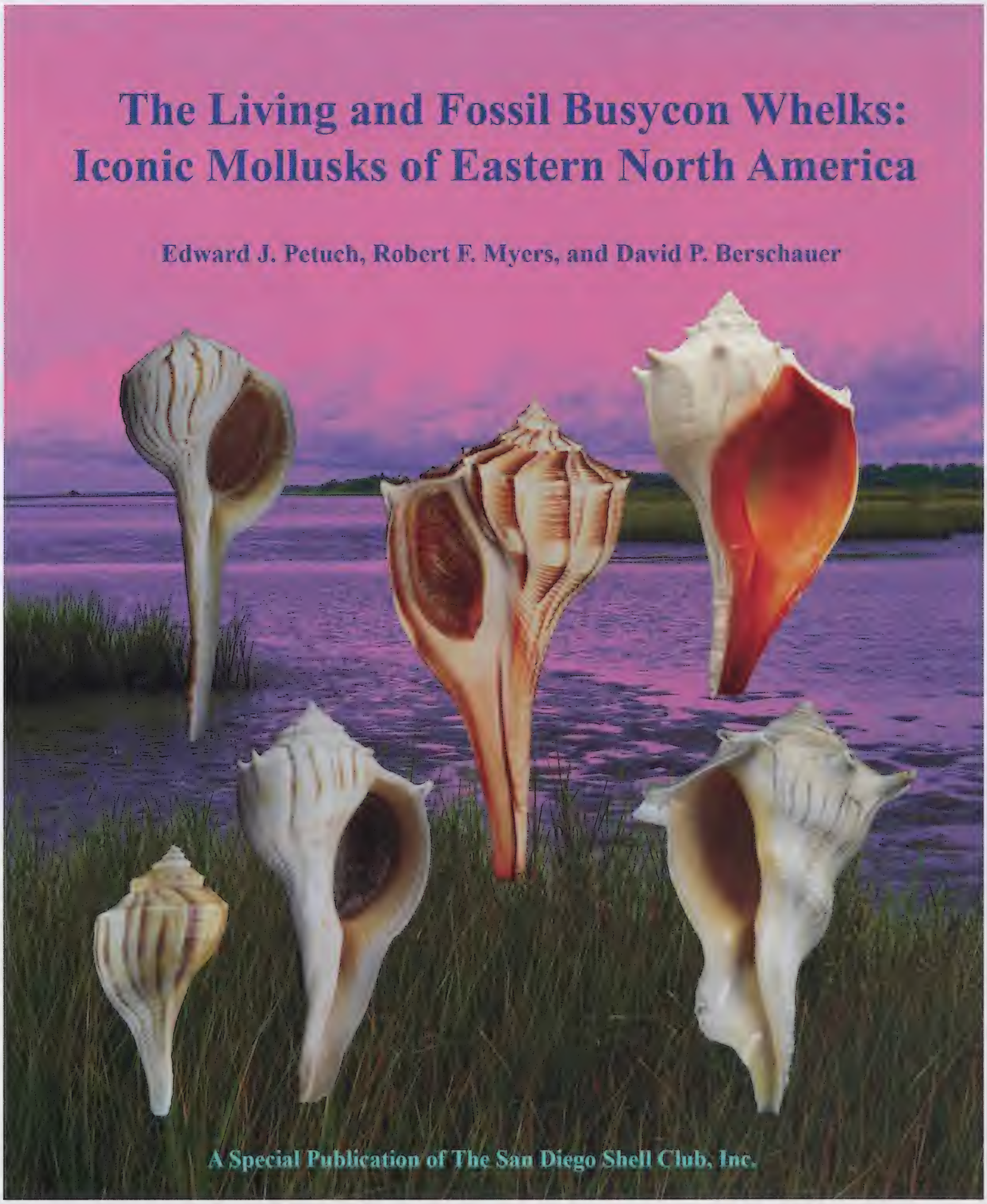
The Living and Fossil Busycon Whelks:
Iconic Mollusks of Eastern North America
Edward J. Petuch, Robert F. Myers, and David P. Berschauer
A Special Publication of The San Diego Shell Club, Inc.

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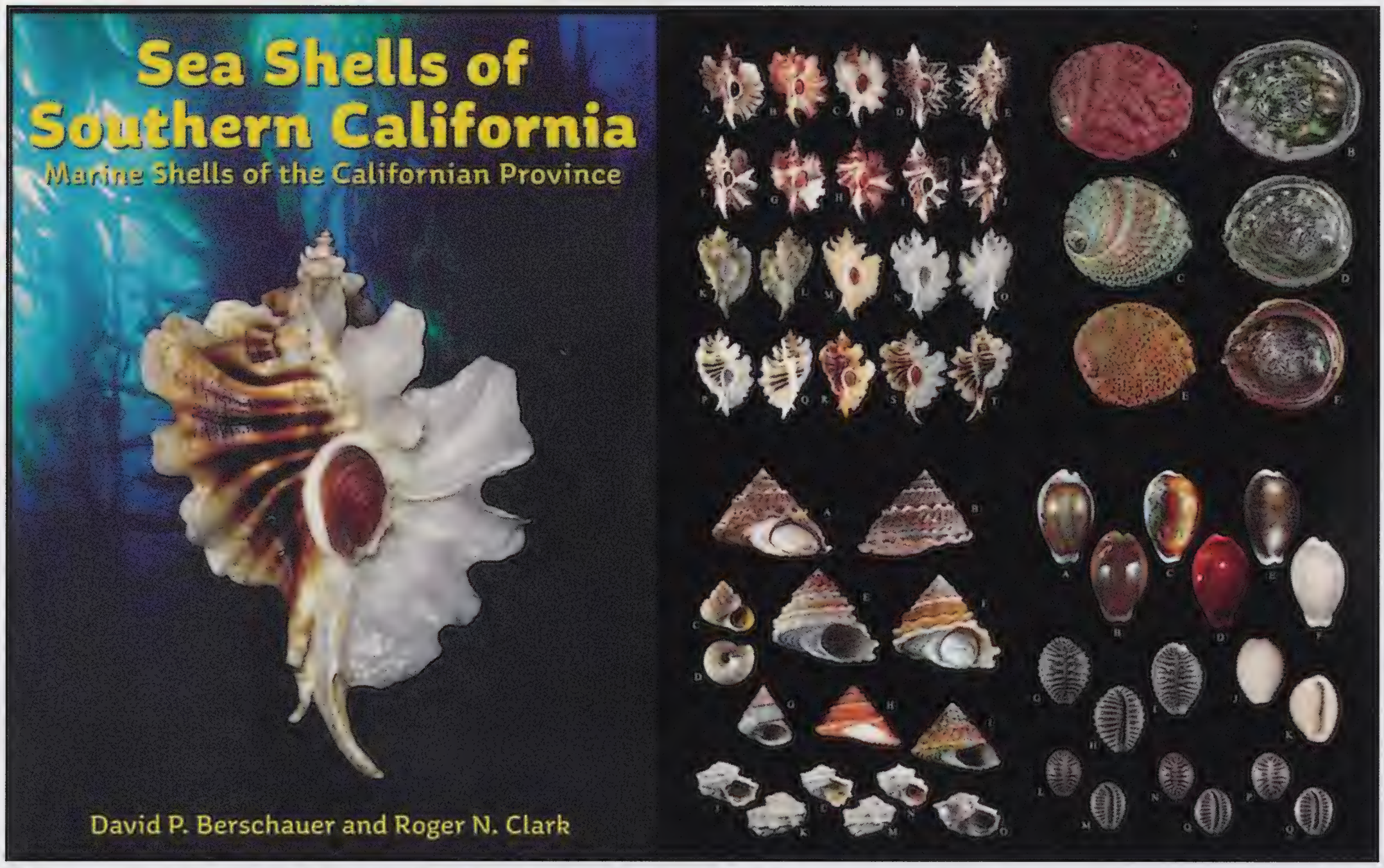

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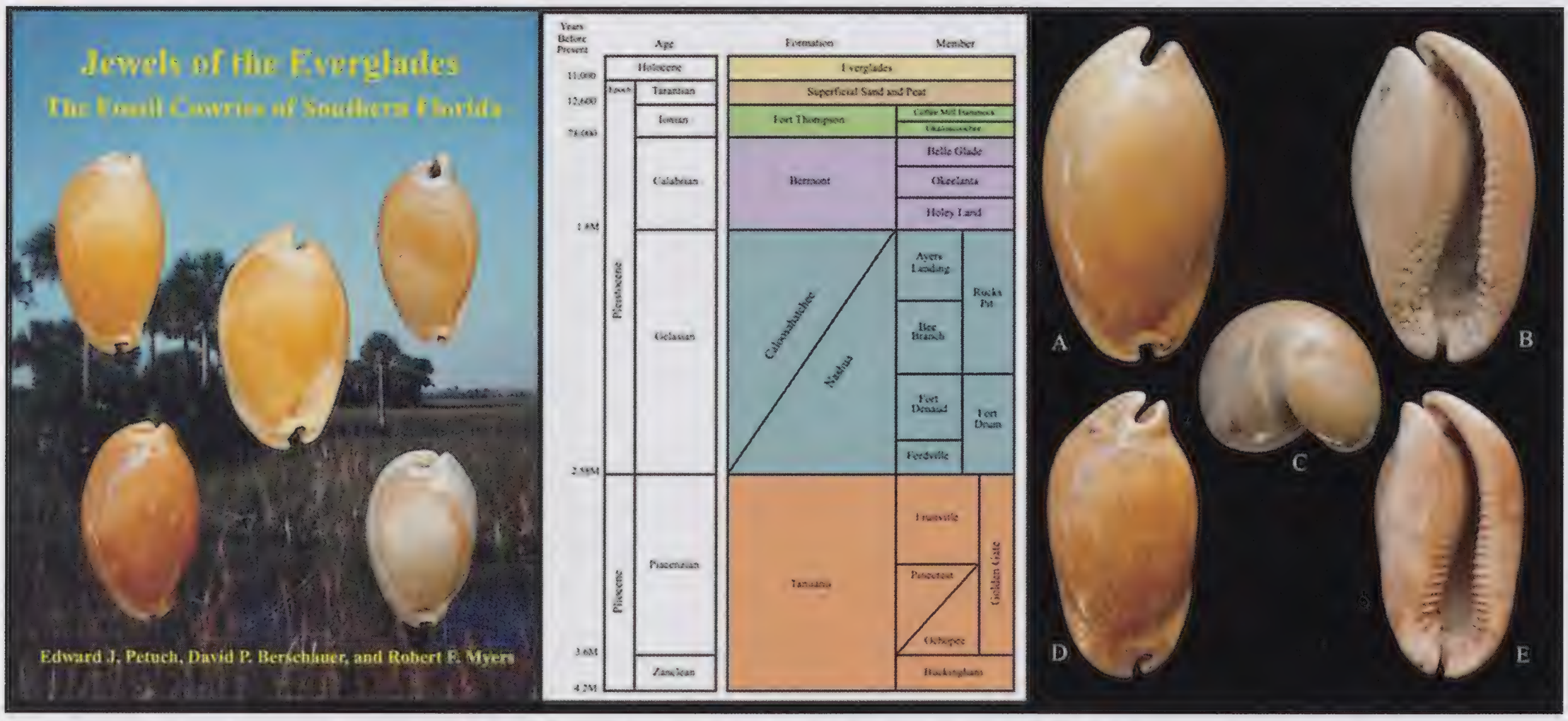

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Volume: 55 THE FESTIVUS ISSUE 1

Florida's Fossil Cowries:
Miocene to Pleistocene
John D. Daughenbaugh
and
Randall Bridges
Why This Book?
The authors provide a taxonomic assessment of all currently described Florida species and related genera from the Miocene through the Pleistocene, accompanied by an overview of the environmental conditions prevailing at the time of their existence as reflected in the geology of the era. The authors have relied on the taxonomic and geological works of the original authors to the extent possible, in many cases utilizing their own words. Two new species are introduced and a uniform format for presenting the Plio-Pleistocene species is utilized to facilitate comparisons and identification. Contains 125 high resolution color plates that offer additional help in identifying specimens.

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Back cover: *Pomaulax geummiae* Berschauer & Petuch, new species, Paratype 1 measuring 107.3 mm in height and 116.7 mm in width. (Photos courtesy of David P. Berschauer) (Cover artistic credit: Rex Stilwill).

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